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New concepts for port design using indigenous natural processes are formulated and proposed which will provide cost effective solutions to the problem of port design in the new world of shifting defense realities. The concepts proposed are: (1) building the ports structure with electrolytic mineral accretion and dialytic ice formation, (2) cables and energy transmission from sea water, and (3) drydocks, lift bridges, various off-loading and port facilities by osmotic pump action using salinity differences. This is obtained by evaporation or freezing. The pump action is enhanced by counter current multipliers and exchangers. Desert land port facilities are accreted, cooled, and supplied with water by the action of evaporative osmotic pumps. This report has a large bibliography.

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CONCEPT STUDY FOR MILITARY PORT DESIGN USING NATURAL PROCESSES

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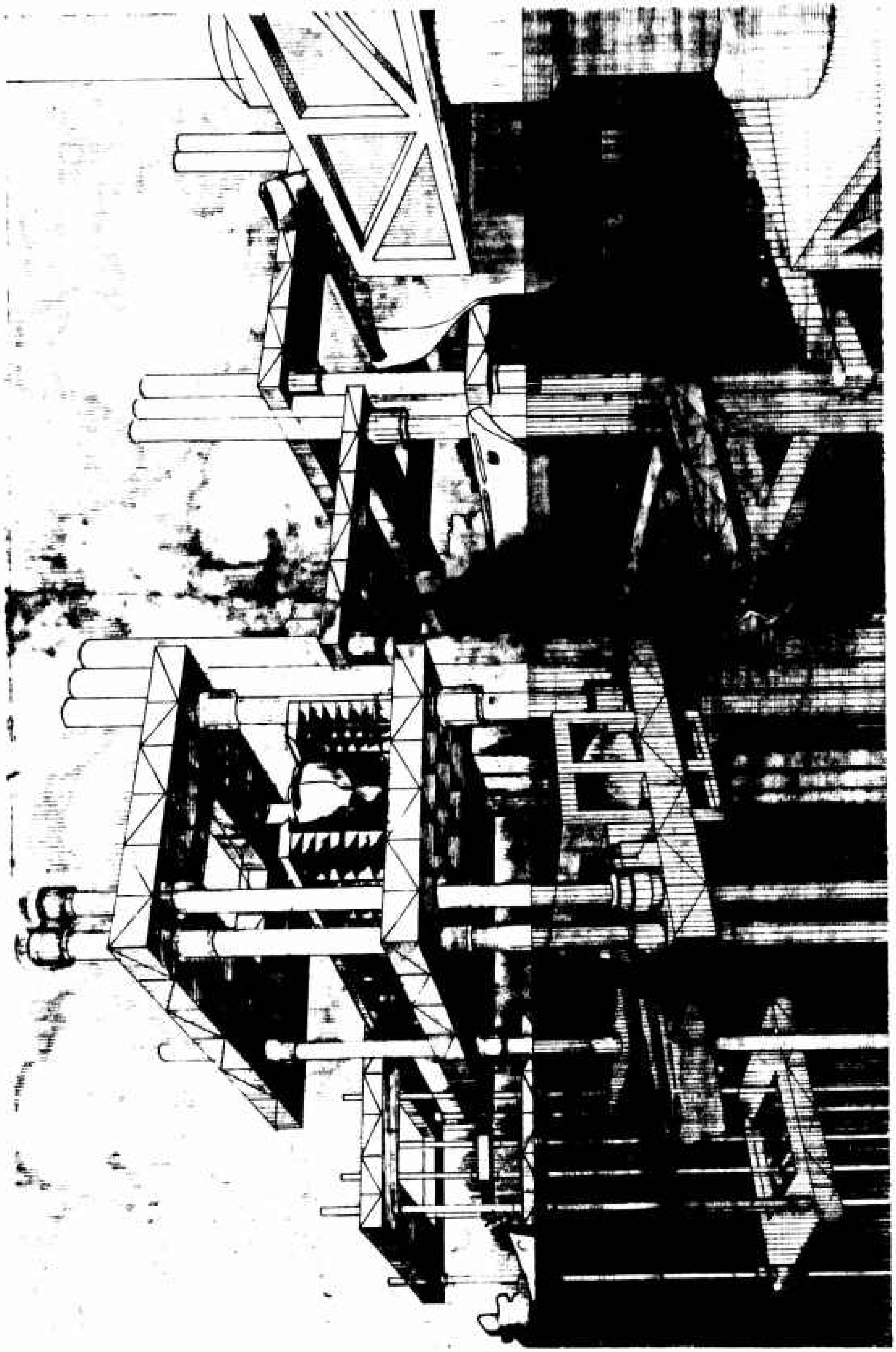


I. CONCEPT STUDY FOR MILITARY PORT DESIGN USING NATURAL PROCESSES

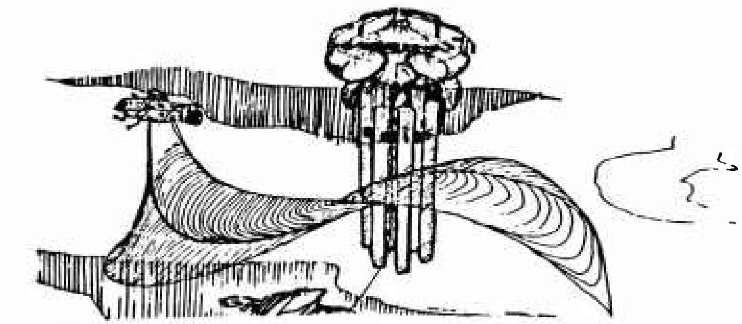
United States Navy operations in the new world are steadily expanding and increasing in complexity. Many new difficulties are being experienced with conventional port design because existing construction techniques require time expenditures and space requirements which may not be compatible with shifting defense realities. New and novel concepts must be formulated and analyzed to produce viable cost effective solutions to the problems of port design.

Insufficient attention has been paid to the possibility of using reversible natural processes as building construction technologies which are economical, energy-cheap and ecologically sound. Such processes are especially applicable to military port design where time requirements are fluid and space needs are stringent. Thus they may require speedy use of indigenous materials in a variety of available settings.

In this quickly changing political world any proposal for attacking the problem of ports for the Navy includes other issues as well. That is, it should address the following:

1) the use of cheap materials closeby to eliminate transportation need
2) new technological concepts to allow the material to be put into organization by a process integral to the material
3) the use of indigenous energy for assembly
4) the use of reversible, recyclable materials.

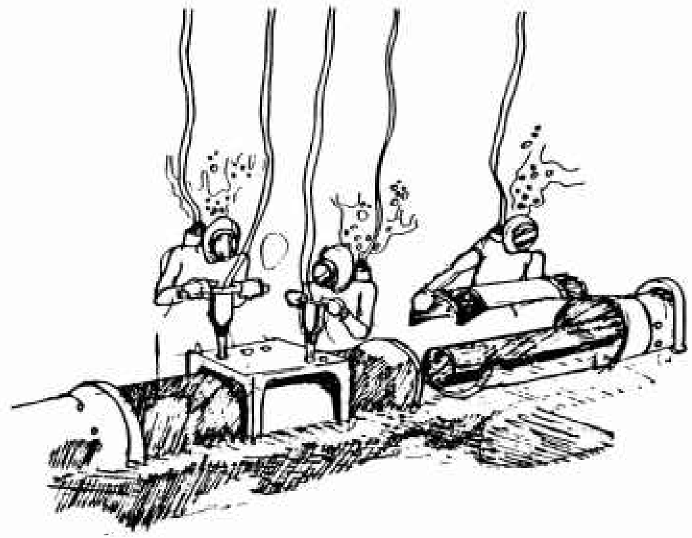
This approach to port design can lend solutions to other problems of ports design -- that is,

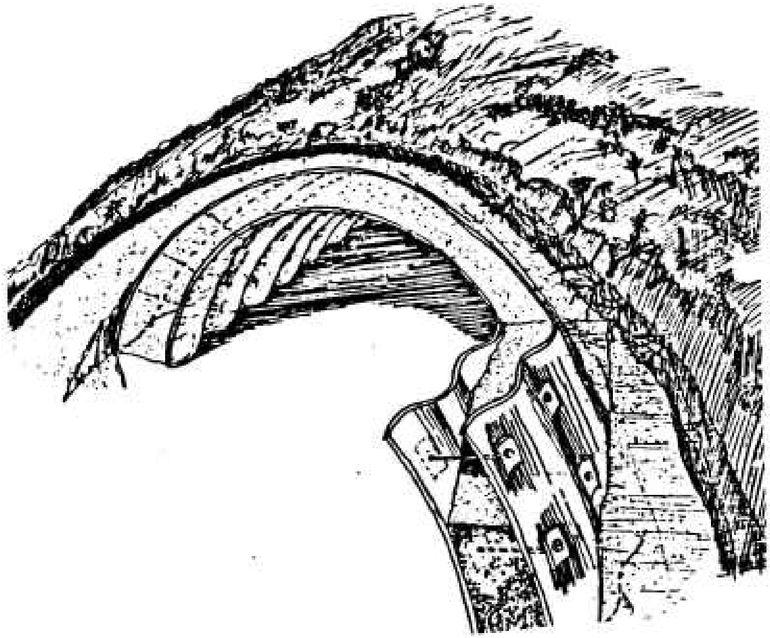


their function:

These related functions are:

1) overhaul and repair of ships
2) servicing of ships
3) acquisition and/or exchange of materials at ports
4) ships functions such as sensing, communication.



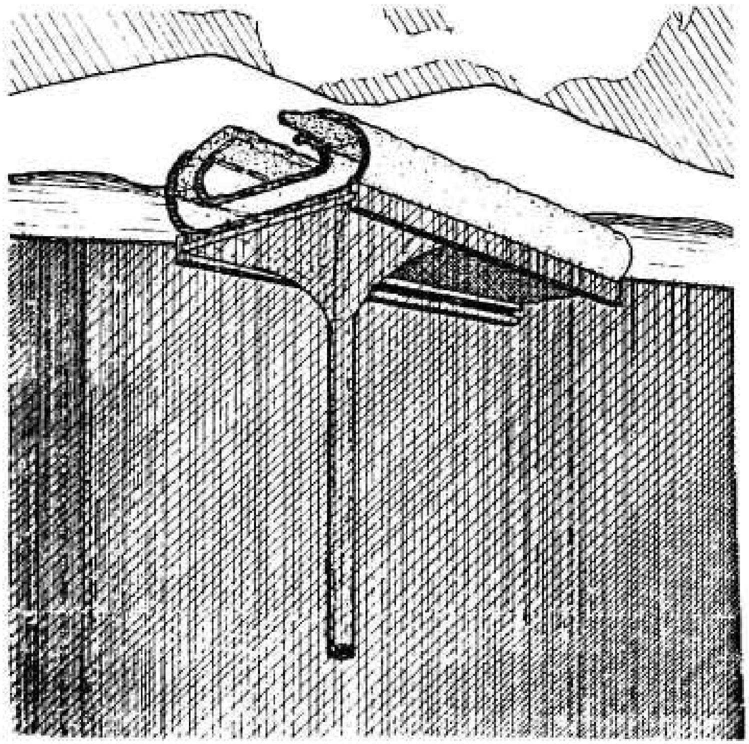


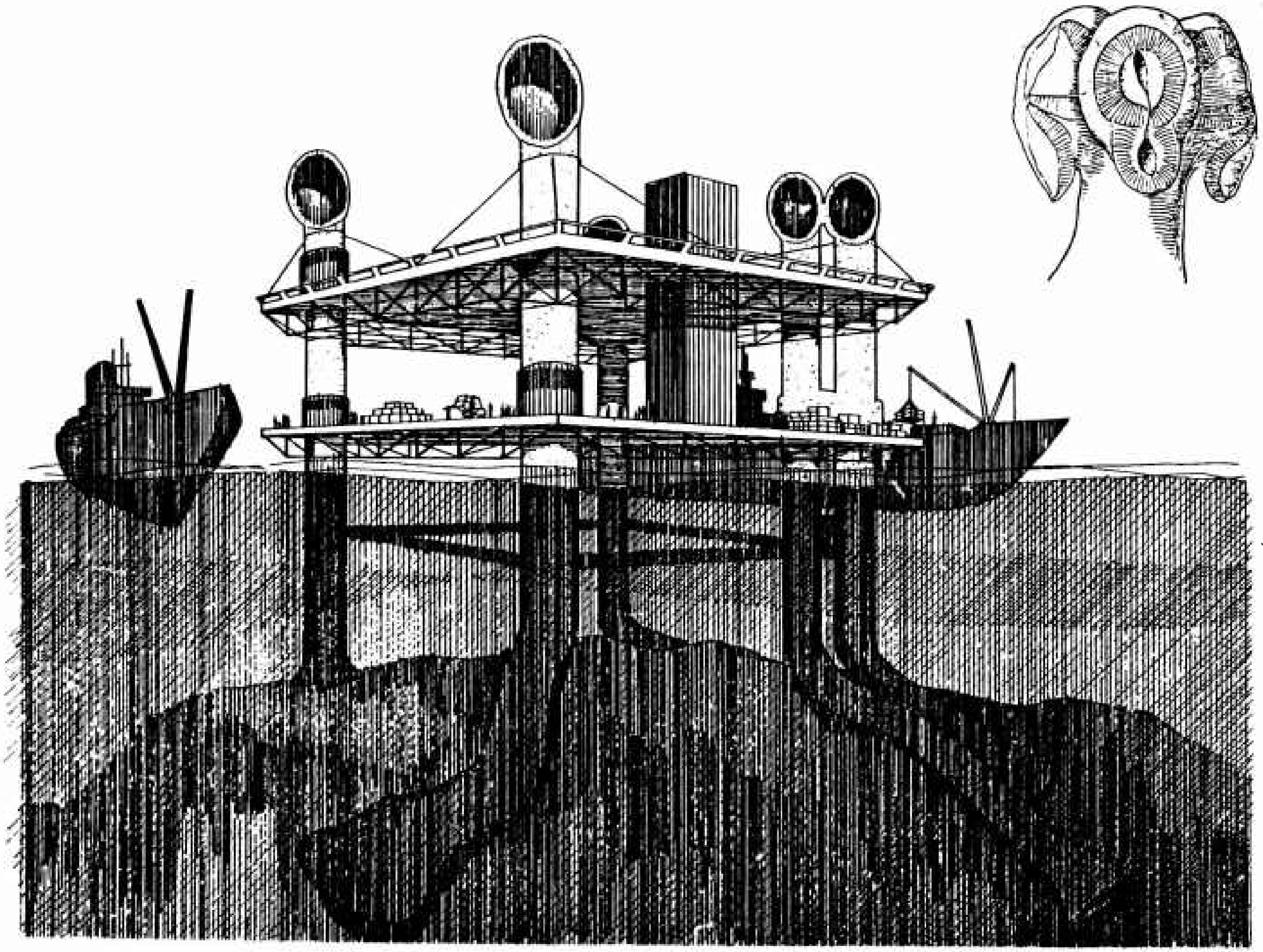
In a remote location the importation of materials, labor, energy, and supplies are costly. Ship repair with available materials and elimination of labor would be advantageous. Materials acquired as much as possible from the natural setting, and servicing, repairing of ships as an ongoing process, is ideal.

Natural processes design applied to military ports is comprised of the following:

1) available materials, which are
2) put into organization or constructed by natural process means, with an
3) indigenous energy source
4) have self-sensing repair and regulation through a process integral to the systems material (1) and organizing system (2)
5) a way of sensing exterior environmental changes and communicating that information.

It can now be seen that, for instance, ship repair and the sensing function are part of a total design based on adapting biological analogy.



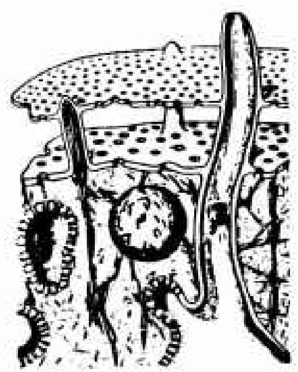


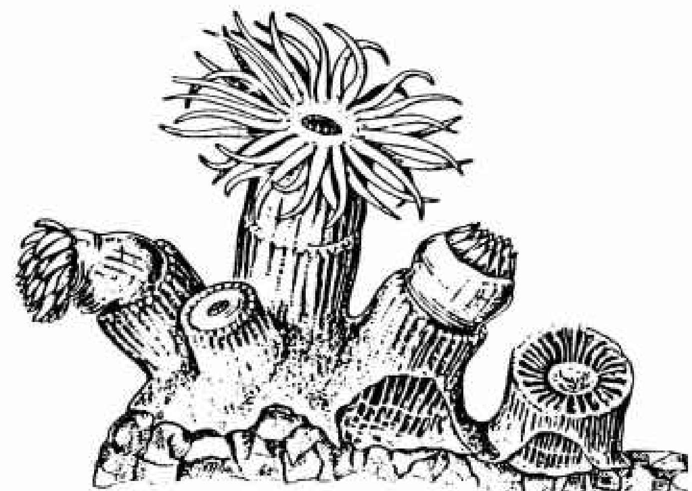
A. Design with Natural Processes in the Ocean

Military port designs are in the main based on technology devised for use on dry land and for less climatically extreme environments -- that is, prefabrication and assembly of standardized elements which are installed on or in an immobile foundation. The fact of the ocean's volumetric movement of water in the form of waves, current, etc. is then viewed as a major problem for these structures. Seawater which contains vast quantities of minerals and elements has the ability to dissolve most substances. It acts to corrode and dissolve most structures placed in it, cover them with encrustations of its minerals and organic matter.

This study will emphasize building with the natural physical, chemical, biological, and climatic processes of the ocean and the climatic regions, and in particular, how to build and protect military ports. The ocean and climatic environment are opportunities for new ways of building with natural processes.

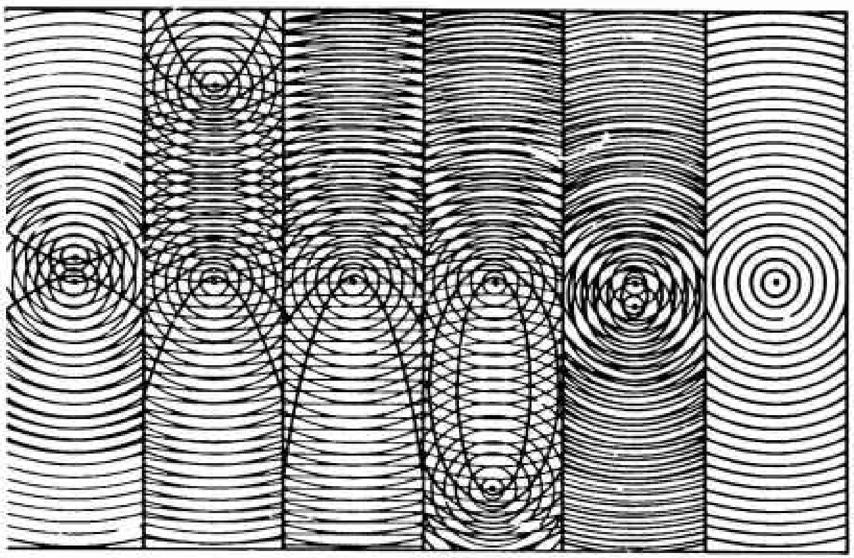
Building with natural processes is to build like a natural system does; that is, (1) using only the most common and abundant resources, and (2) putting these into an organization by means of technologies which are indigenous to the environment, (3) self-regulation through a process which is integral to the system's material and organizing system. The self-regulating process entails a way of sensing a need for change, reorganizing, re-collecting material and redistributing it according to the new organization. Thus there is material, ways of distributing the material, organizing principles, ways of sensing, and means of reclaiming material.

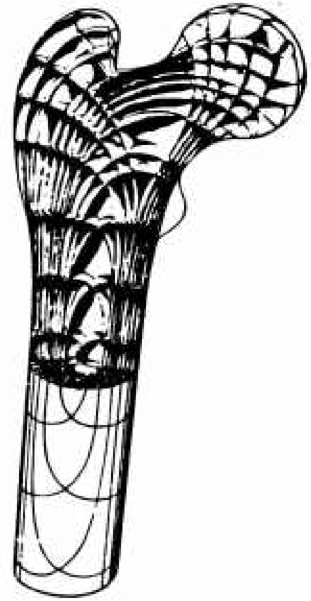


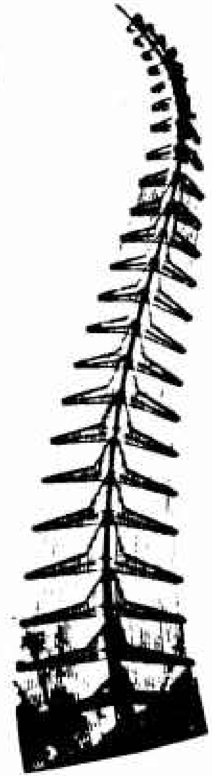


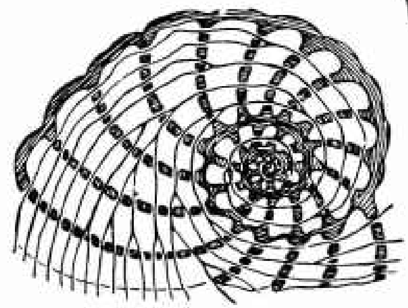
Design with natural process is drawing from the "experience" of evolution and integrating those principles into technology. It is an examination of properties of entire systems and elements, their effects on each other and their performances based on interactions of a complex system. Ultimately their capacity to organize material in a complex way and reorganize it depends upon the interrelationships among elements, not upon the number of elements added.

The advantages for building ports in this way are potentially enormous. The savings are in energy normally used for prefabrication, the imported material required, installation time, repair time and costs of replacement and obsolescence.









In the ocean environment the following is true:

A) The most common and abundant resources are:[1]

1) elements in seawater -- that is, beside hydrogen, oxygen, one cubic mile of seawater contains

chlorine	salt	89,500,000t
sodium		49,500,000t
magnesium		6,125,000t
sulphur		1,880,000t
calcium		1,790,000t
potassium		1,609,000t
bromine		306,000t
carbon		132,000t

and 51 other minerals and elements.

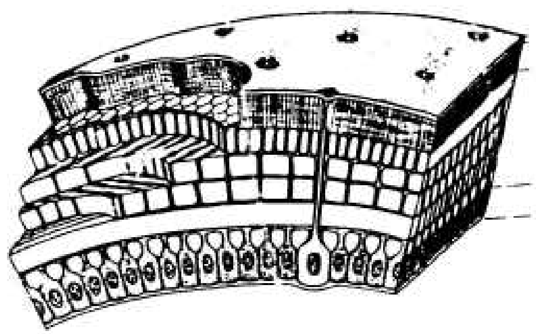
2) earth -- clay, sand, rocks

3) ice

4) organic materials

5) also manmade rigs and ships

The means to manipulate these materials are to dissolve, evaporate, solidify, liquify, plastify, elastify, associate and dissociate (as ions), decompose and compose.



B) Some of the most indigenous technologies or means to distribute and gather materials are:

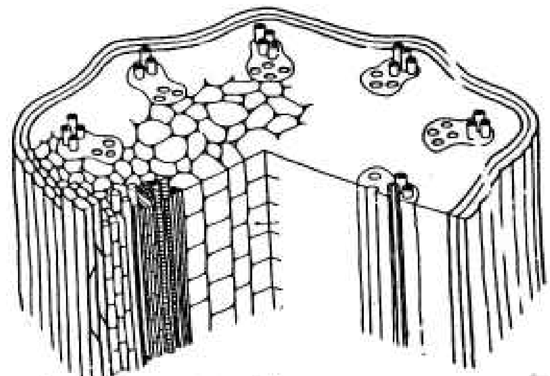
1) flow of fluids

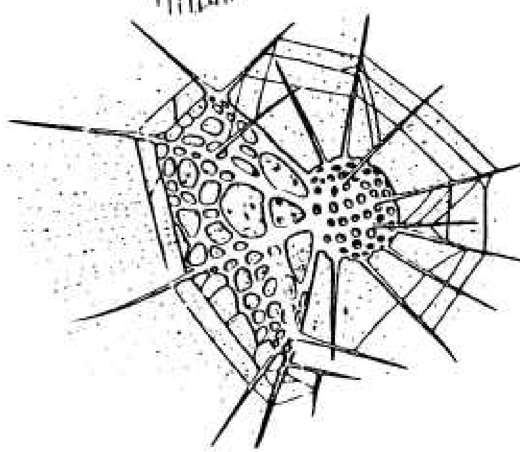
2) electrical current and ionic movement in seawater

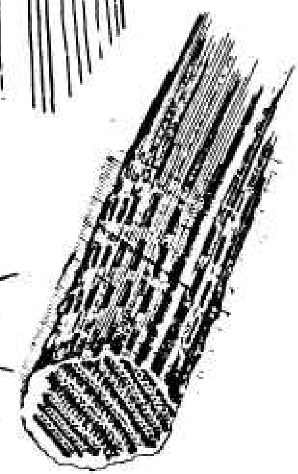
3) gas flow

4) gravity

The means to change material's properties are chemical reaction, electrical charge, ionic charge.

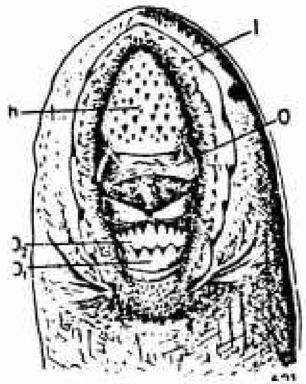


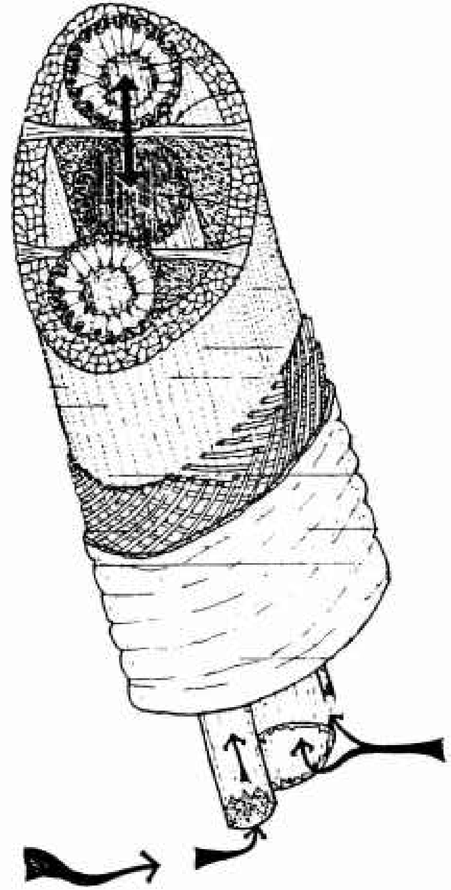


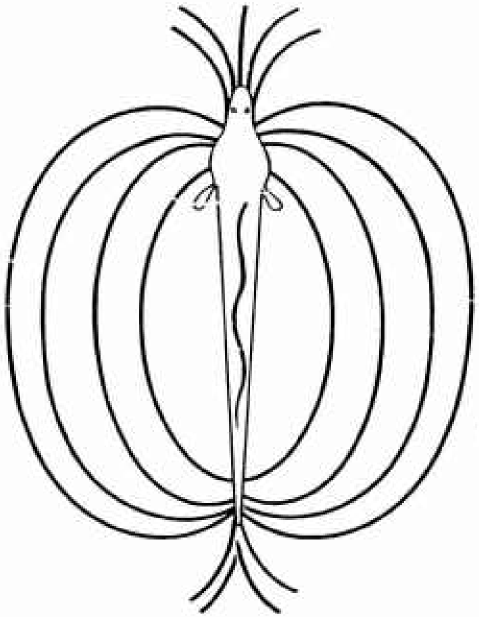


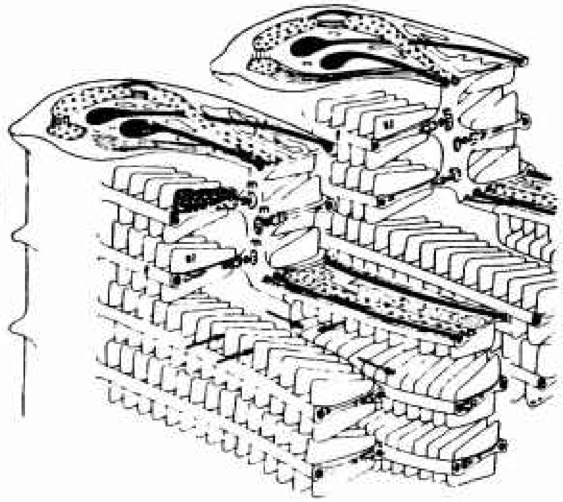
C) Some types of sensor most readily applicable to the ocean environment are:

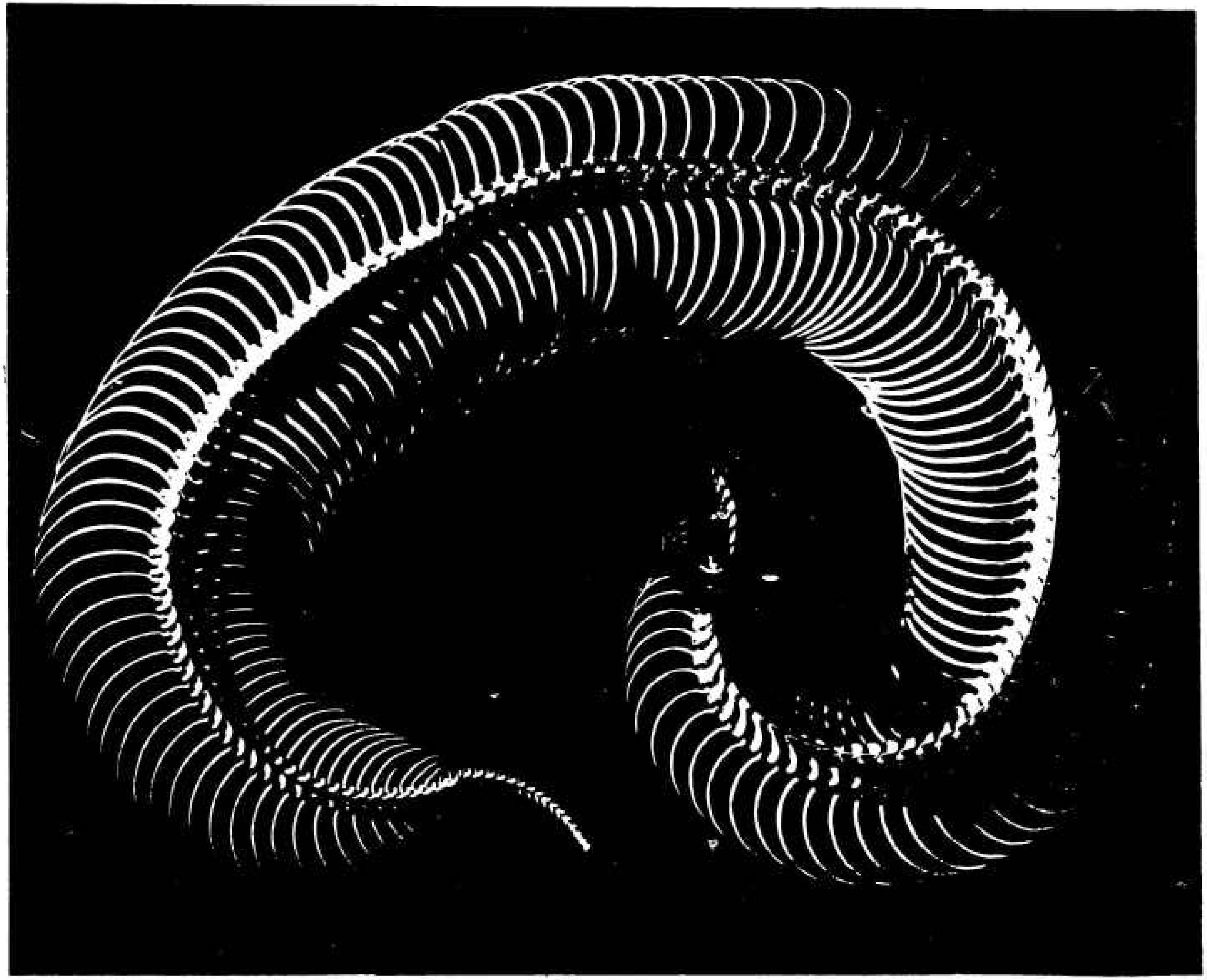
1) chemical sensor
2) thermometer
3) pressure sensor
4) wave sensor
5) some photosensor
6) microphone
7) electrical sensor









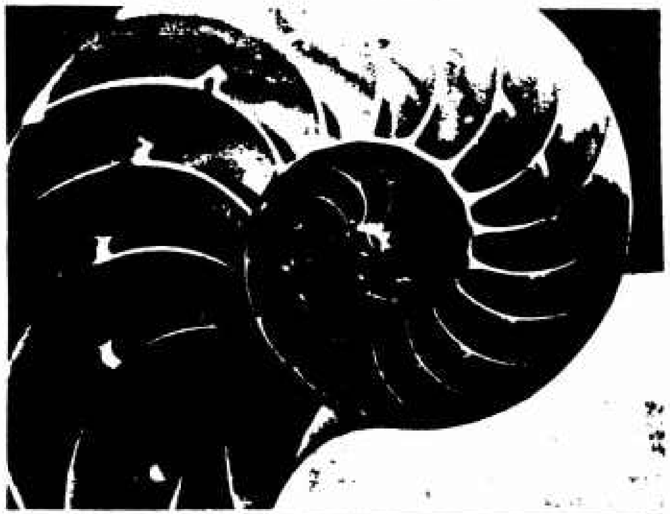


II. MINERAL ACCRETION STRUCTURES

Mineral Accretions (like seashells and bones)

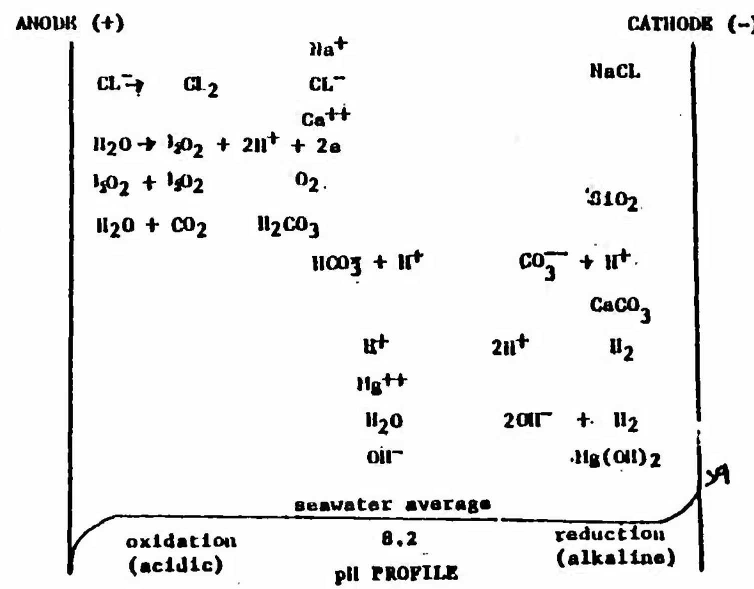
The ability of seawater to dissolve and corrode many substances in it and also to cover them with encrustations of minerals and organic matter can be harnessed. These natural accretions have been found to have the bearing strength of concrete.

Sea mollusks make their shells by accreting minerals through use of an electric potential.

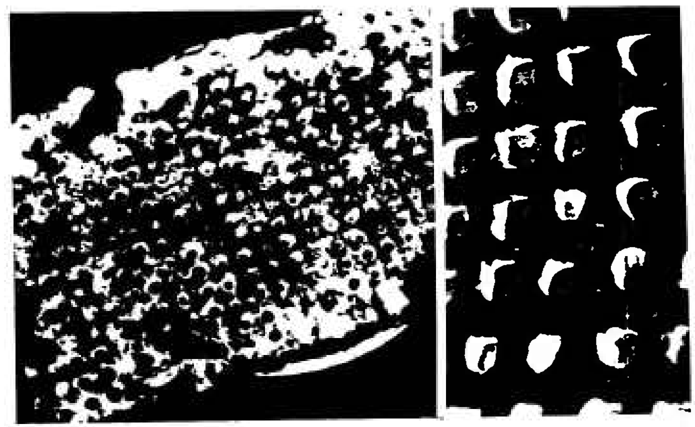


Metals in seawater are subject to such electrolytic processes and ions can be precipitated onto surfaces. A metal armature is hooked to electrodes with a charge and submerged in seawater, the electrical current produces an electrolytic deposition of minerals onto the armature framework. The cathode gives off hydrogen; the anode, oxygen. A power supply from a battery charge of about 4.8U at 200mA to hardware cloth, anode of carbon about 10cm x 2cm in an aquarium 3 x 1½ x 2 for a period of 500 hours produces an accretion of 10mm.

Using anodes of lead, carbon, or iron, the electrochemical reactions are as follows:



The material is accreted either due to concentration, ion attraction, or electric migration.[2] However, finally after much calcium carbonate precipitation the solution becomes more alkaline and bucite and other crystals are precipitated out inhibiting the precipitation and further growth of calcium carbonate crystals. Magnesium hydroxide bucite is the most common precipitate, calcium carbonate being usually 5 - 15% of the total. At resting intervals biological organisms transform the unstructured materials into a stronger substance. The following are the precipitates which appear on submerged metal mesh: brucite, $Mg(OH)2$, average of 80%, aragonite, $CaCo_3$, average of 10%, calcite, $CaCo_3$, average of 7%, and other 3%.



The cathode shape to be encrusted is a surface made up of linear wires. This surface, for which the metal rods are reinforcing and template, can be fashioned into the shape of dams, dock facility, underwater habitats, storage facility, ship's hull.

As accretion occurs gases are given off (hydrogen, chlorine). These are then available in the seawater to buoy the structure's volume to any desired position.

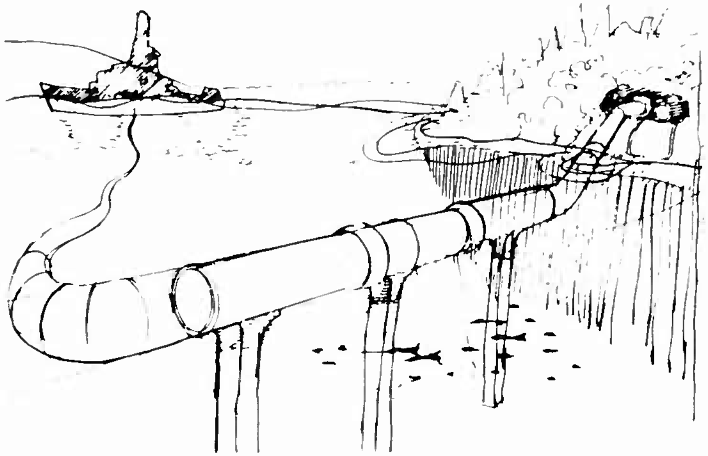
Cables and pipelines can be "accreted on" in situ, or pre-accreted in an undersea accretion factory.

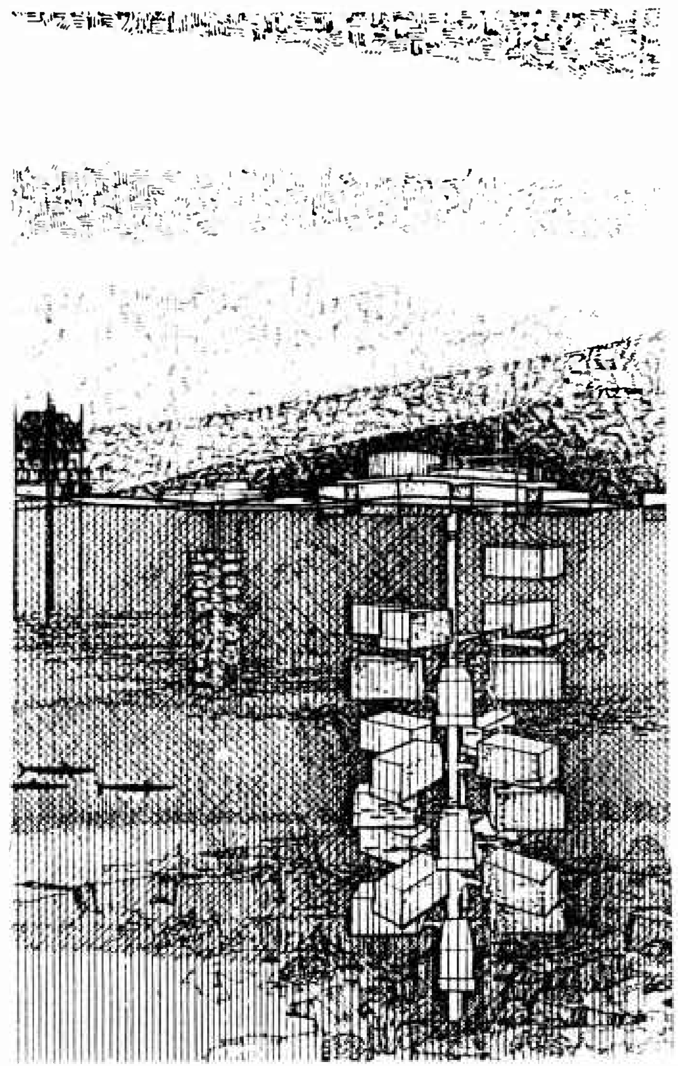
A movable anode generator can pass over an area, selectively depositing mineral accretion on surfaces where it is needed.

The linearity of cables and pipelines means accretion can occur much more rapidly than in cases of surface coverage. The place to be covered with accretion is the electrical cathode itself, thereby speeding the process.

A portable mineral accretion device, which uses a rock-fusing nozzle can extrude mineralized pipes.

The metal hull of a ship can also be used as the anode.





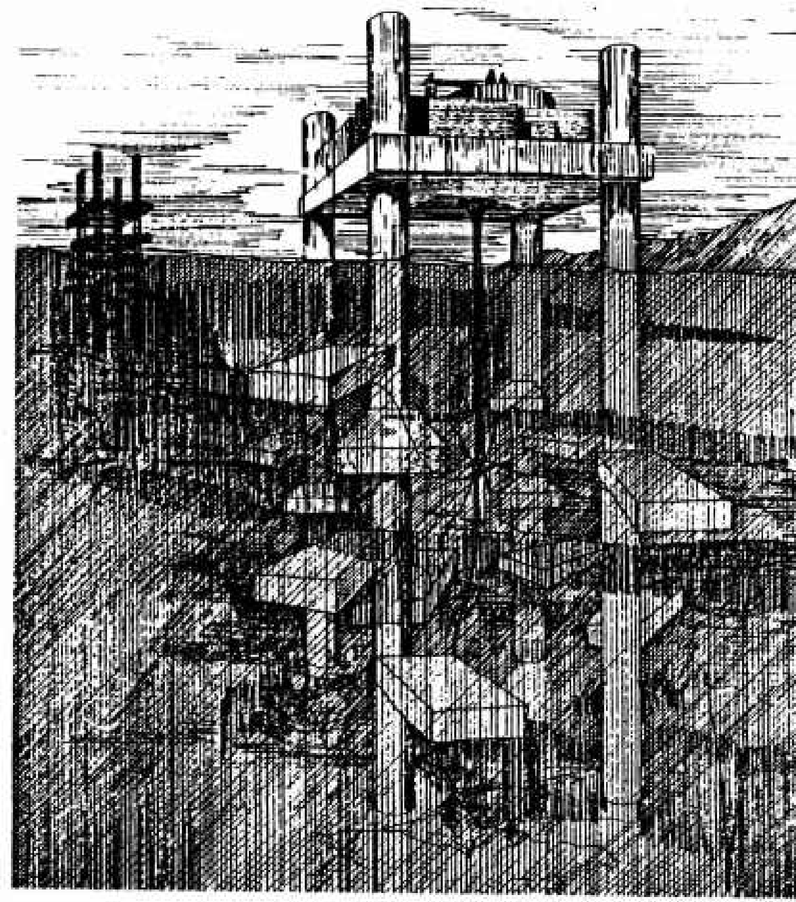
The factors controlling the saturation state of calcium carbonate are variable.

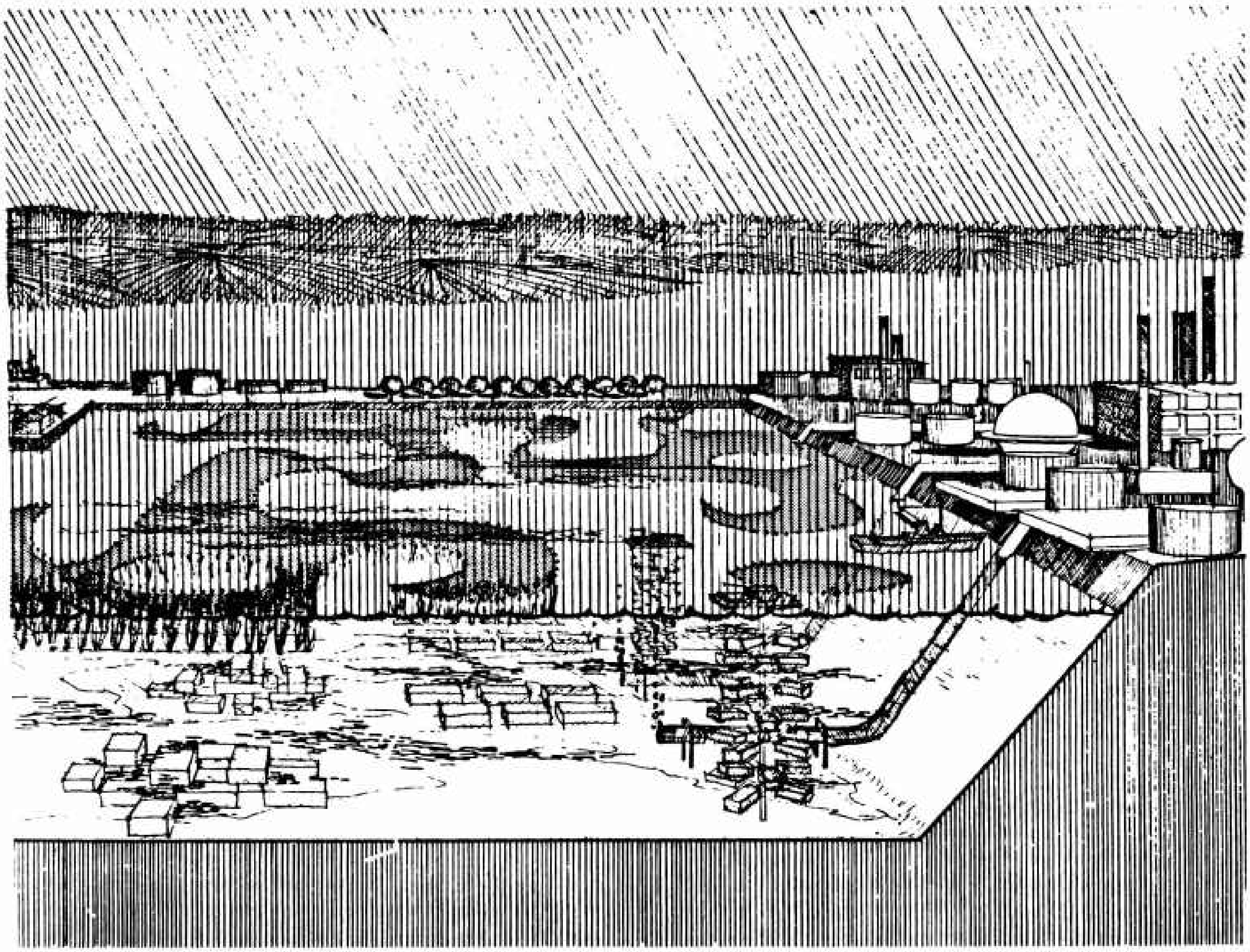
"Major factors controlling the saturation state of calcium carbonate in the oceans are pressure, temperature and the CO_2-carbonic acid system. Pressure is directly proportional to the water depth. Temperature is stable in deep water (below about 1.5 km), but has significant variations with latitude, currents and upwelling in near-surface waters.

In addition to temperature variations, other factors including exchange rates across the air-water interface, biological activity, and surface to deep water mixing rates can affect the carbonate concentration in near-surface waters."[9]

In summary, it should be noted that the technology works in most ocean areas because magnesium hydroxide, the most common precipitate, is plentiful in all oceans. The calcium carbonate precipitate obtained is mostly dependent on the precipitation technique used and also affected by the amount available in the seawater. In certain nearshore regions chemicals are very concentrated and available.

The deposited material can be reclaimed by adding chemicals and reversing the electrode position. This is the technique used by archaeologists and marine scientists to fight encrustation. The metal wire on the surface serves as the anode.

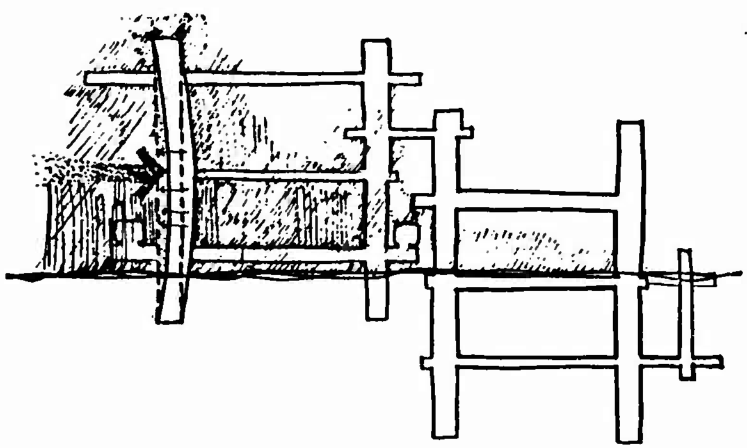




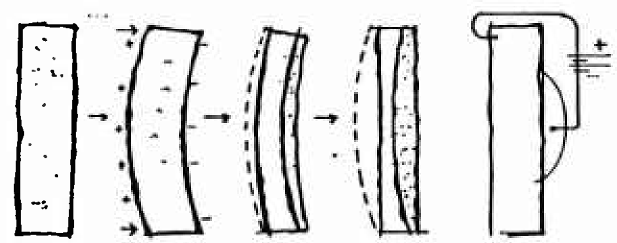
Peizoelectric effect

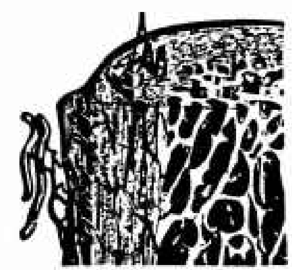
A more subtle automatic reclamation and redeposition of accreted materials to enhance the structural properties is possible. It is the peizoelectric effect of transforming mechanical energy into electrical and vice versa. An electrical potential develops when the material is strained.[4] It could be used to sense deformation and stress in the accreted cables or pipelines and accomplish self-reorganizing repair through the migration of electrically charged minerals.

For instance, in bone a mechanical deformation generates an electrical current. (When a negative charge builds up on the concave side, new bone from the positive convex side fills in to straighten it.) "An electrical current applied to an undeformed bone, caused growth in the area of negative charge, no loss in the area of positive. The reason is that slight stress generates a charge that attracts or repels electrically charges ions in the blood plasma bathing the bone cells. Removal of stress causes reversal of charge and an opposite effect on charged ions. This electrical pumpting system is responsible for translating mechanical energy into electrical energy."[5]



This is an especially exciting example of complex self-organizing interrelationships among elements that is found in natural processes. This natural process building system uses material and energy indigenous to the area, has its own inseparable installation, repair, and reclamation process integrated into one organization. The capacity to organize material and reorganize it in a complex way depends upon interrelationships among elements which are the results of millions of years of evolution. The design is ready to be recognized and used.

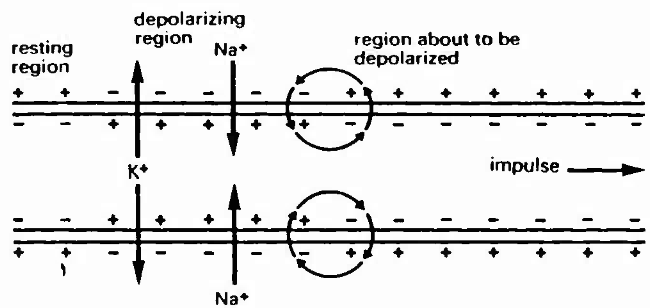


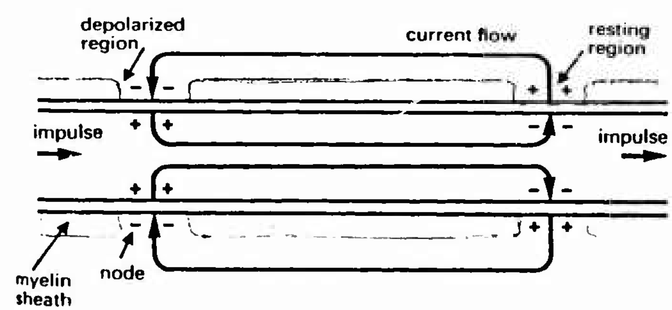


Ions moving across an osmotic membrane can create an electrical impulse. This ionic impulse is the natural process way of generating a current in seawater. An electrical cable in seawater is like a nerve in blood, blood fluid having nearly the same composition. In the human body, ionic leakage across a membrane from the potassium rich "seawater" of the nerve to normal "seawater" of the blood, can propagate a nervous impulse. The original research on nerves by A.L. Hodgkin was done by studying cables in seawater for the equations which apply to nerves in blood.

Simply put, the nerve is a membrane with potassium rich seawater inside and ordinary seawater (with sodium) outside. "In other words, there is a lot of chloride, a lot of sodium and a little potassium outside. Within the cell and the axon, however, there is a little sodium and a lot of potassium. The natural law of equilibrium would make the sodium tend to diffuse from the external environment into the axon and the potassium in the opposite direction. However, because they are in solution, the potassium and sodium chlorides are partially dissociated, or ionized. The sodium and the potassium ions have electrical charges as a result of this ionization, and because of this they are sensitive to electric fields or differences in potential. It can now be seen that a difference in concentration of potassium and sodium ions between the outside and the inside of a neuron must be counter-balanced by a difference of charge and thus produce a potential difference between the external environment and the neuron. This can be summed up by saying that the neuron is polarized with respect to the external environment."[6] The membrane leaks ions in an effort to reach concentration and charge equilibrium of the ions. Potassium and sodium do this because they are very similar in size being next to each other on the periodic chart and therefore easily slip through membrane pathways.[7] A sudden large flow of ions in an attempt to reach equilibrium causes a pulse, and this propagates a signal along the nerve. Calcium plays a role of reading the membrane for this sudden reversal.

A (myelin) sheath is developed to insulate the nerve to prevent leakage, except at certain interval nodes. The membrane — a phospho-lipid — is like an osmotic membrane which allows ions to pass based on size and electrical charge. More precisely, "the signals used by nerve cells to transmit information consist of electrical currents generated across their surface membranes. The current flow through the intracellular and external fluids and result principally from the movements of charges carried by sodium, potassium, calcium, and chloride ions. Compared with insulated metallic materials, such as cables, nerves are very poor conductors of electricity. The interior of

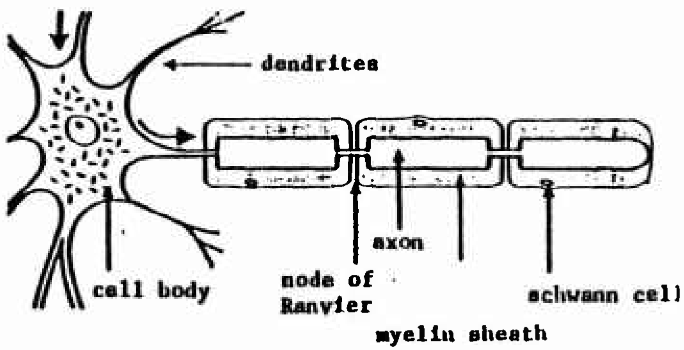




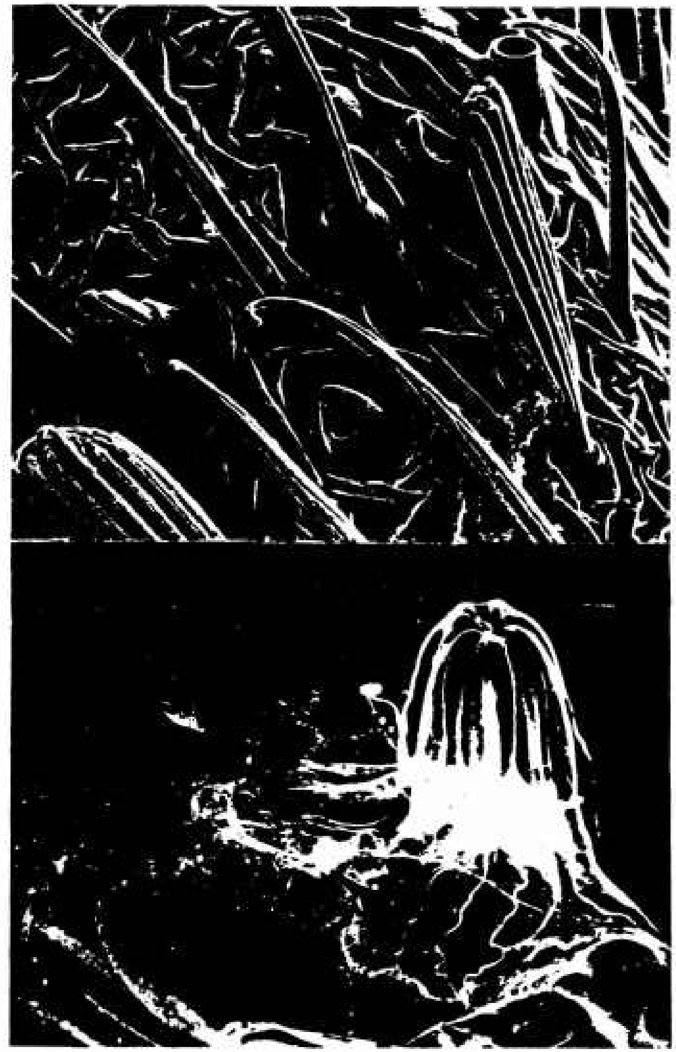
a neuron is separated from the outside by the cell membrane, which is an imperfect insulator and permits some leakage of ions in both directions. The membrane has also the capacity to store and separate electrical charges. These properties impose restrictions on the way in which electrical signals can be conducted.

The general conclusion is that electrical signals can be generated by the membrane without the direct intervention of metabolism, by selectively changing the ionic permeabilities and allowing ions to flow downhill along their electrochemical gradients. With each action the cell gains sodium and loses potassium, but for a single impulse the amounts are small enough for the resultant concentration changes to be ignored.

The poorly insulated nerves use the leakage problems in the system to build up a large charge by the change in ionic and electrical potential across a membrane. It is an example of using what materials are available and an apparent disadvantage (leaks) to tremendous advantage.



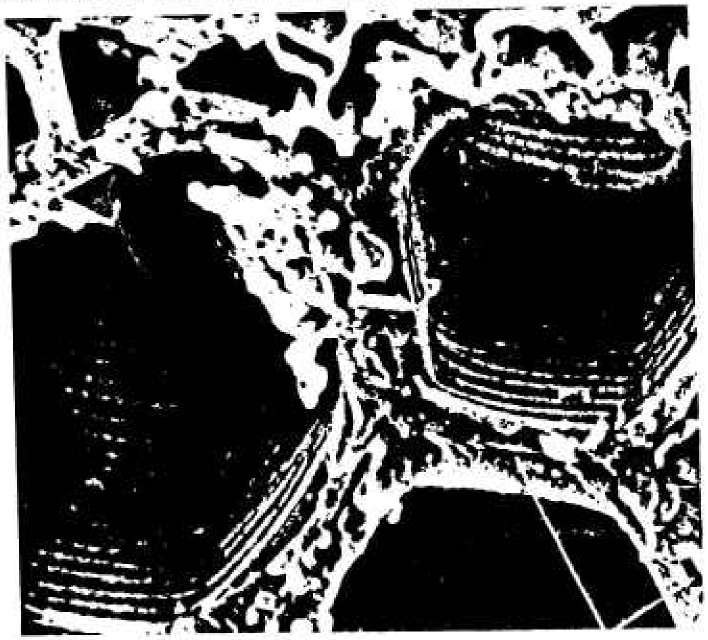
A typical nerve.

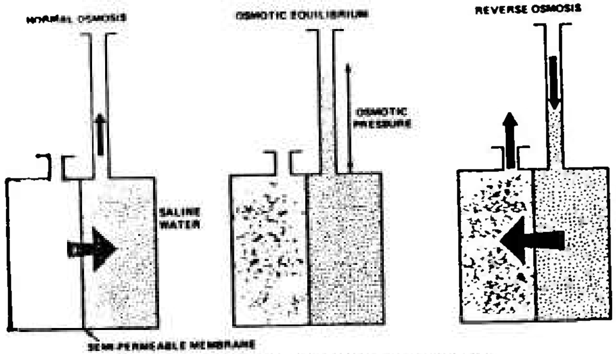


III. SALTWATER-IONIC TRANSMISSION ACROSS MEMBRANES
(for pumping water, creation of electrical impulses, and generation of electricity)

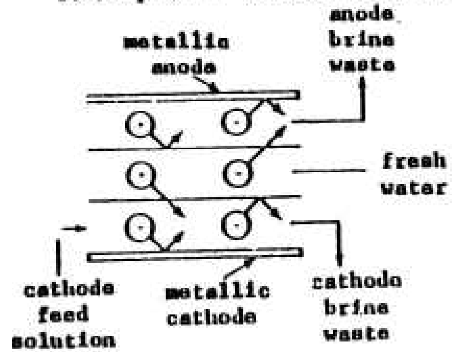
Reverse osmosis and electrodialysis processes are both based on the use of semipermeable membranes to achieve solute-solvent separation in saline waters.

In the case of reverse osmosis, fresh water diffuses through the membrane leaving the salt behind while in electrodialysis demineralization of saline solution takes place by the passage of salt through the membrane. The driving force employed to cause solute-solvent separation in reverse osmosis is hydraulic pressure (some incremental pressure over the osmotic pressure of the solution to be desalted). In electrodialysis, electric current acts as the driving force.*

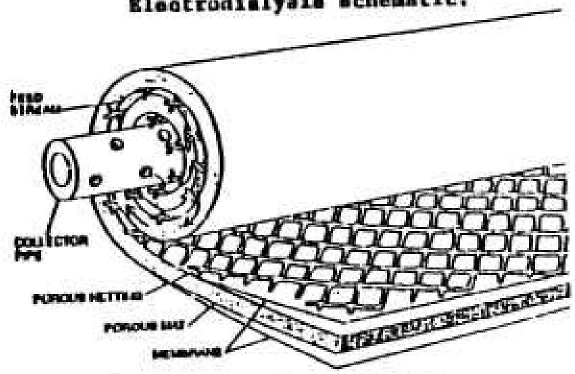




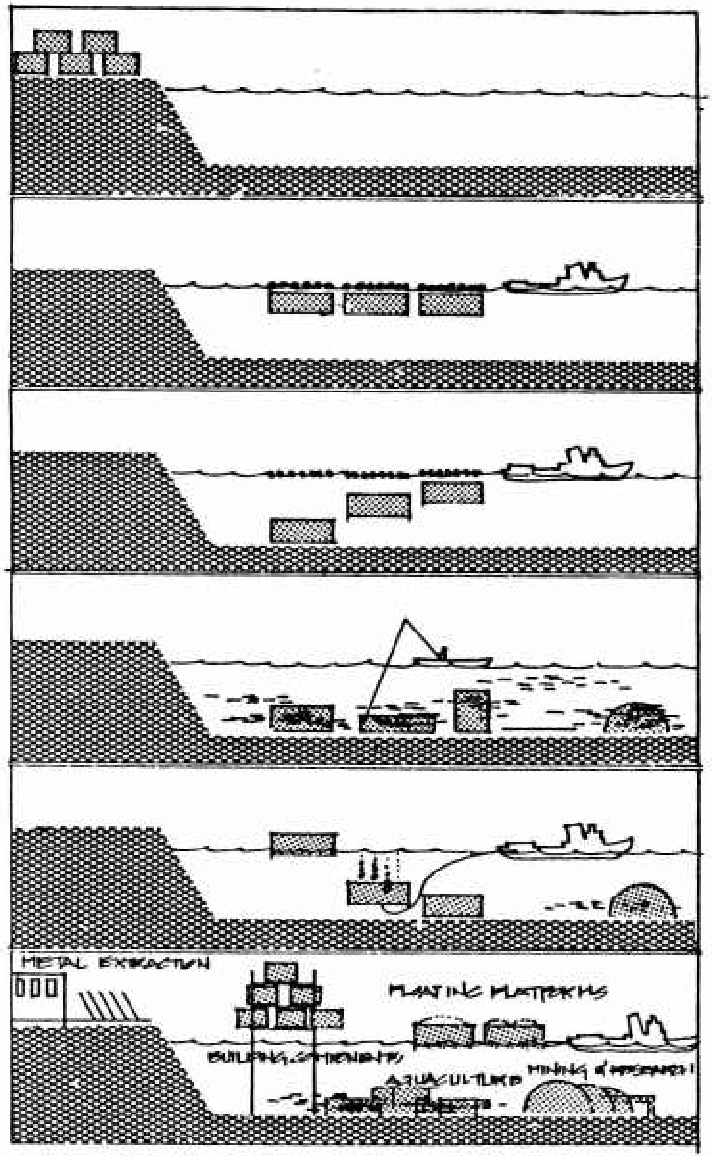
Principles of reverse osmosis.



Electrodialysis schematic.



Reverse osmosis apparatus.



1 FABRICATING FRAMEWORK

2 FLOATING TO SITE

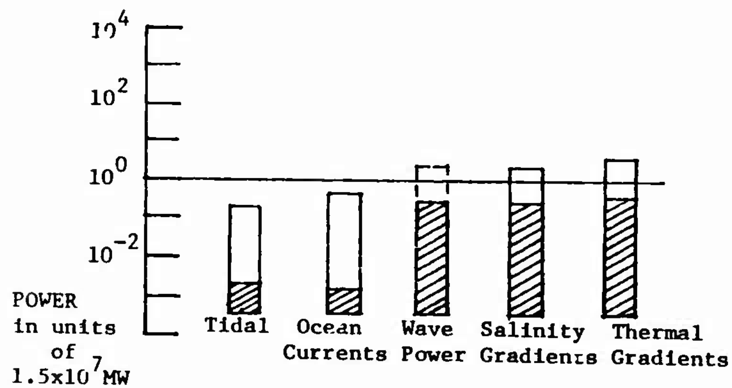
3 SINKING INTO PLACE

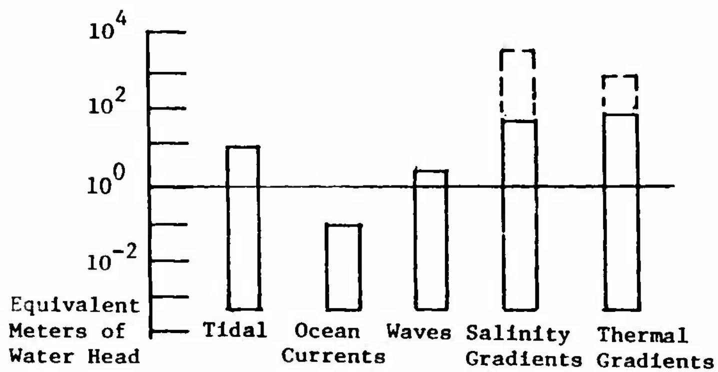
4 UNDERGOING THE PROCESS OF ACCRETION

5 HARVESTING

6 USAGE

Just how advantageous those ionic leaks across membranes can be is immense. Power, i.e. voltage and current generated directly by diffusion of ions across a permselective membrane that separates the concentrated from the dilute solution is one of the greatest potential sources of energy in the world,*' equal to OTEC thermal gradients, and above all others but nuclear and chemical fuels, if the ions used are those in seawater.



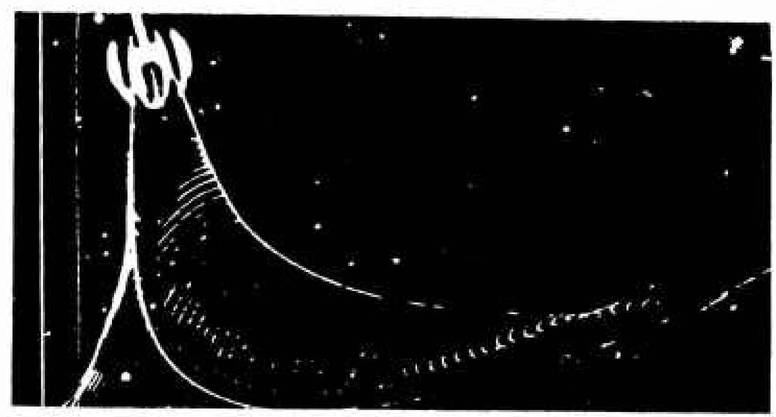


"In the case of freshwater and seawater, the osmotic pressure difference is equivalent to 24 atmospheres or the pressure at the bottom of a column of water 750 feet high.

One way of looking at it is that a 750-foot waterfall exists at the mouth of every river and stream in the world. Few dams are this high. At present the river water irreversibly mixes with the ocean water with no social gain. However, as an example, if half of the flow of the Columbia River were converted into electricity at only 30-percent efficiency, 2,300 megawatts would be produced. This is the size of two gigantic power plants.

Where the Jordan River empties into the Dead Sea, the energy density is even more spectacular. The nearly saturated brines of the Dead Sea have an osmotic pressure of about 500 atmospheres, corresponding to a dam over 15,000 feet high! Every cubic foot of water flowing into the Dead Sea per second could theoretically generate over one megawatt of power." [1]

The cost of membranes and energy cost which are usually cited as drawbacks have been examined by Loeb and Isaccs and found to be "respectable."*[1]



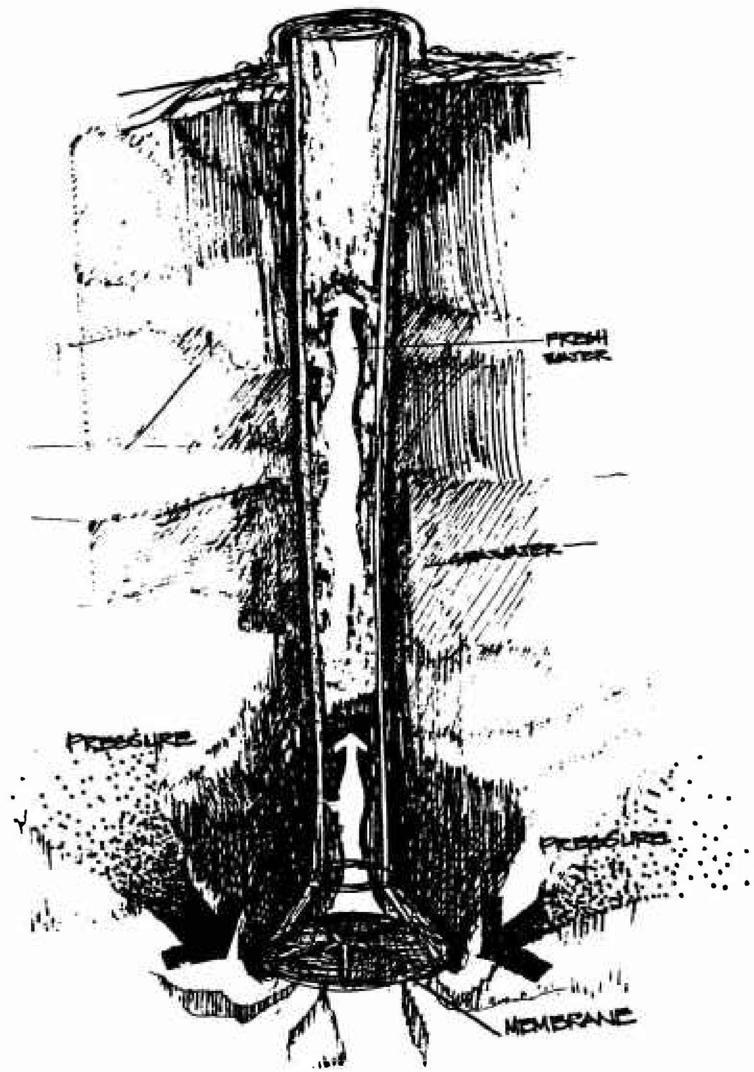
Osmotic pump:

"A pipe open at the top but capped at the bottom by a semipermeable membrane (permeable to water but not to dissolved salts) is lowered into the ocean. Because the osmotic pressure difference between fresh and salt water is about 23 atmospheres under ordinary conditions, the inside of the pipe will at first be free of water. When the pipe is lowered more than 231 meters the pressure difference across the membrane will exceed 23 atmospheres, and fresh water will flow into the pipe and rise to a level 231 meters below the ocean surface.

Now since salt water is about 3 percent denser than fresh water, if the pipe is lowered further the level of fresh water in the pipe will have to rise if the pressure difference at the membrane is to remain at 23 atm. Finally, if the pipe is lowered deep enough water should rise above the surface.

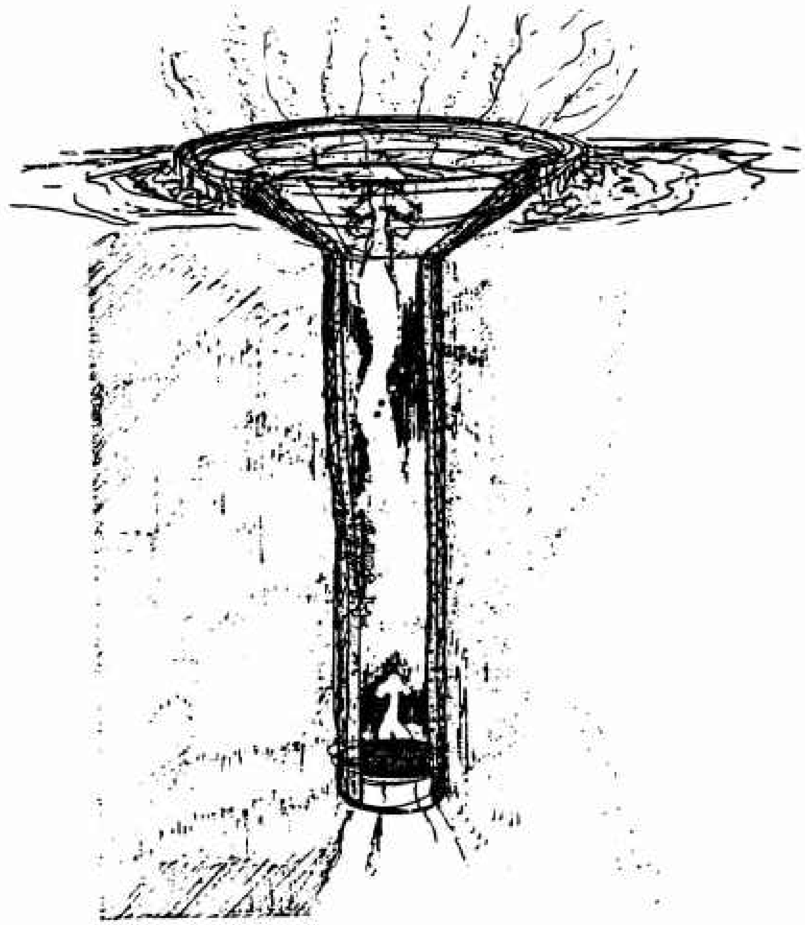
Thus, in principle, if you grant an ideal membrane, we should be able to get a fountain of fresh water from the ocean.

This osmotic pump requires a larger membrane area and a cheap and lasting membrane system. (This pump, like the saline one, moves water against gravity, acquiring potential energy as hydraulic pressure which of course can be translated into useful energy when it is depressurized through a hydroturbine generator.)



Saline pump:

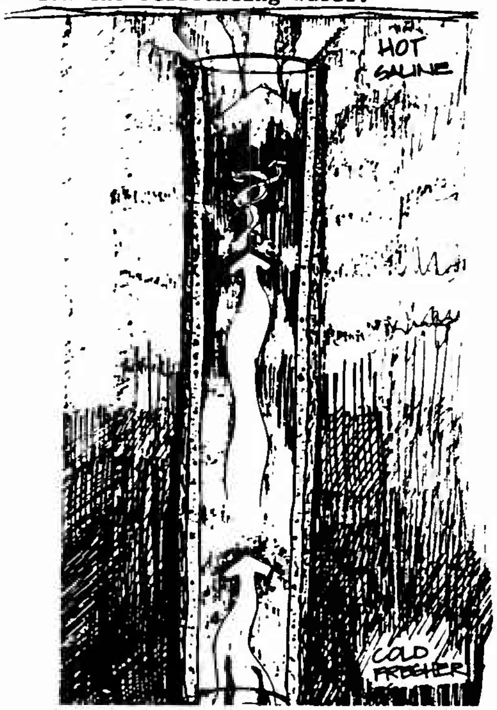
Assume that a membrane permeable to ions of one sign, say to cations (cation exchange membrane), separates seawater and saltier seawater, and that electrodes, i.e. reversible, are at each side of the container. If these electrodes are connected through an external resistance, current will flow and useful energy will be obtained. It's the old nerve impulse idea repeated several times to produce more current. The anode and cathode can also be covered with calcium deposited, thus obtaining pipe protection. To obtain the differences in normal seawater and more saline water a natural saltwater pump and freshwater pump will be used. That is: tropical and subtropical oceans have warm, salty water near the surface and cooler, less salty water below. A seemingly perpetual fountain may be made by dropping a tube to the bottom, and pumping water to the surface. The pump can then be removed and the fountain will continue itself. If the tube is closed off by a one-way membrane at the bottom, that enclosed water will become increasingly saline due to evaporation and more water will rush in to equalize the concentration. This extra salty seawater or brine acquires potential energy as hydraulic pressure by virtue of water permeation from the dilute to the concentrated solution, against the hydraulic pressure gradient. It is then a perpetual pump that is activated by water evaporation in hot air thus producing the brine (or, for that matter, freezing of ice in cold air to provide the brine). The pipe/cables can be vertical or bent but must have vents to the surface.

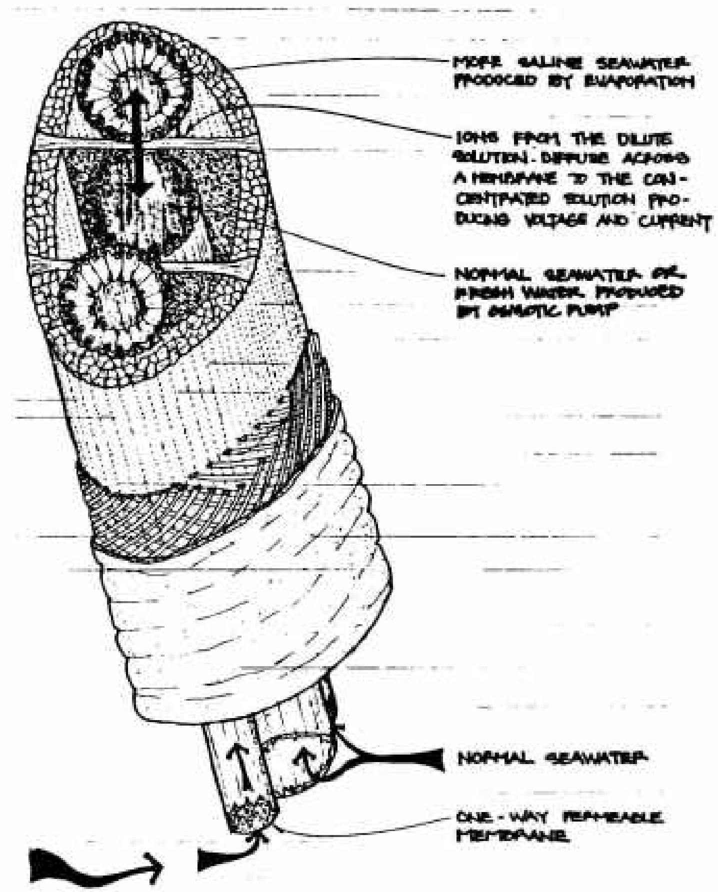


Ocean thermal pump:

An ocean thermal energy pump utilizes the temperature difference between warm surface waters and cooler deep waters.

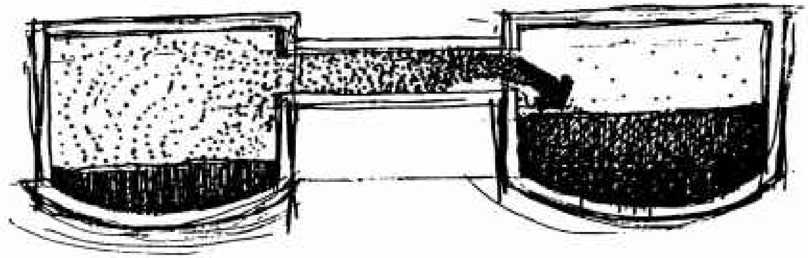
"Tropical and subtropical oceans have warm, salty water near the surface and cooler, less salty water below. A seemingly perpetual ocean thermal energy vertical current or fountain may be made by dropping a tube to the bottom and pumping water to the surface. The pump can be removed and the fountain will continue pumping. As the cold, fresh water from the bottom rises, it warms the surrounding water and is then lighter than the saltier top water. Thus the flow continues upward. Even without the tube it would continue since the rising water would exchange heat much faster than salt with the surrounding water." [13]





Vapor pressure compensation:

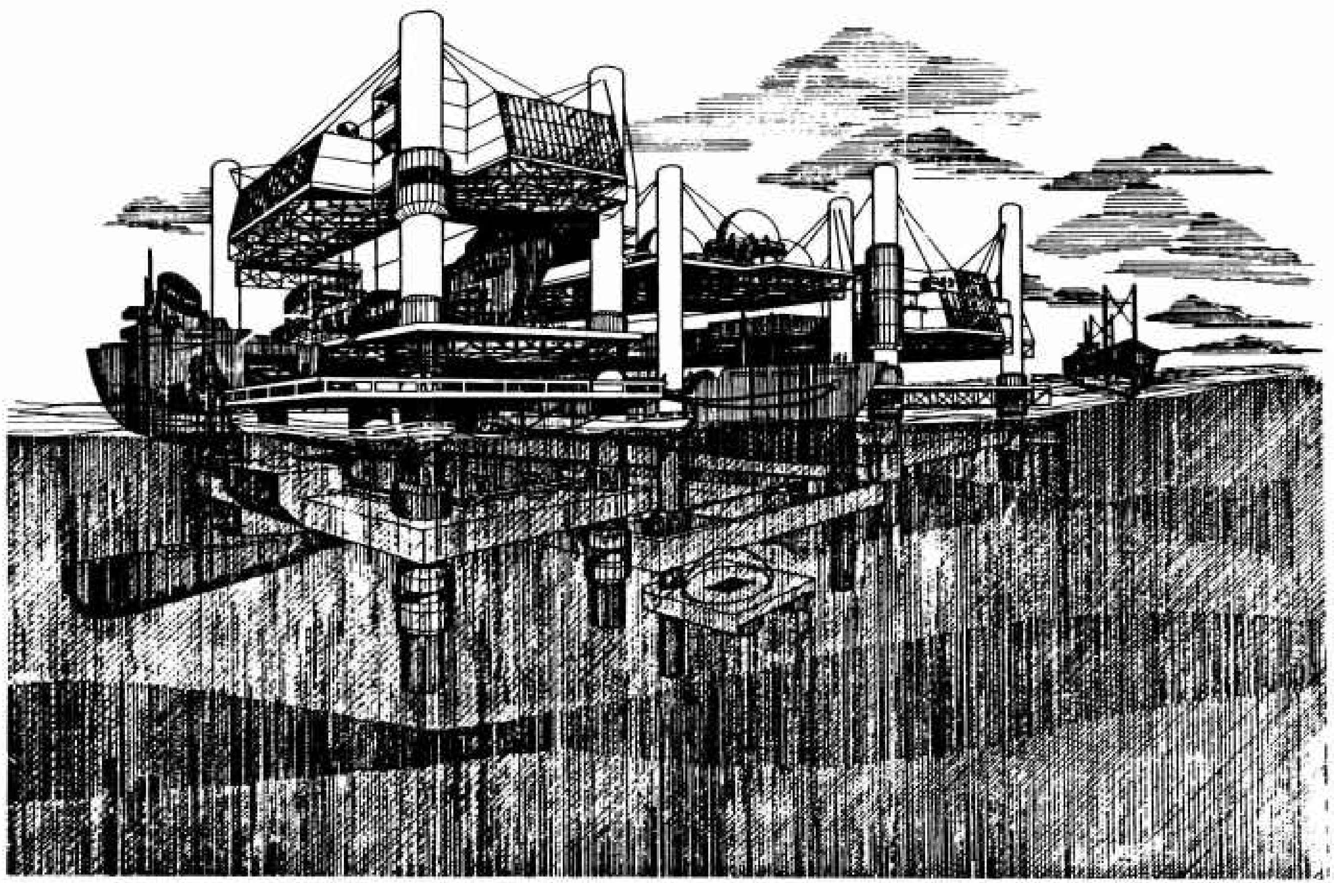
There is another way to transfer freshwater to a more saline solution extracting energy on the way, this time without use of a membrane; that is the vapor pressure of the air acts in place of the membrane.



"Power can be extracted utilizing the vapor pressure difference between fresh (or low-salinity) and salt (or high-salinity) water because at the same temperature, water evaporates more readily from fresh water than it does from saltwater. Due to this lower vapor pressure on the saltwater side, water vapor will rapidly transfer from fresh water to salt water in an evacuated chamber. If a turbine is interposed between the two solutions, power can be extracted.

When the vapor transfers between the two solutions, it carries energy in the form of the latent heat of vaporization. This is the heat that is released by the vapor to its surroundings when it condenses and is absorbed from its surroundings when it evaporates. More energy is transferred by the latent heat of vaporization than is present in the vapor motion. This heat transfer would tend to slow down the process and eventually stop it unless the heat were returned to the freshwater reservoir or the system were flushed before much of the energy had been extracted.

To overcome this problem, evaporation and condensation can take place on opposite sides of an efficient heat-exchanger plate, as it is in vapor compression desalination. Such a model was built at the University of California Scripps Institute of Oceanography. It consisted of a spiral heat exchanger that doubled as a mixing pump when the unit was enclosed in a slowly rotating cylinder."[14]

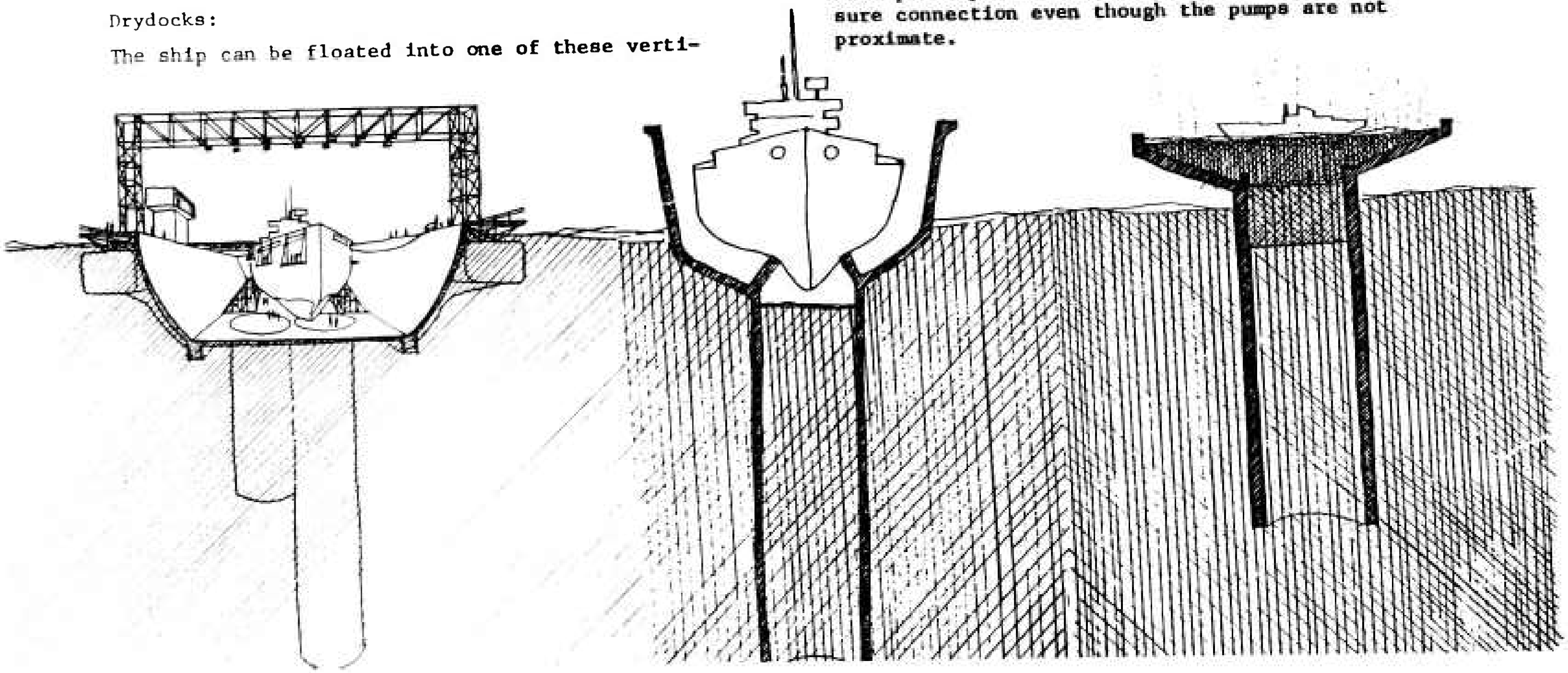


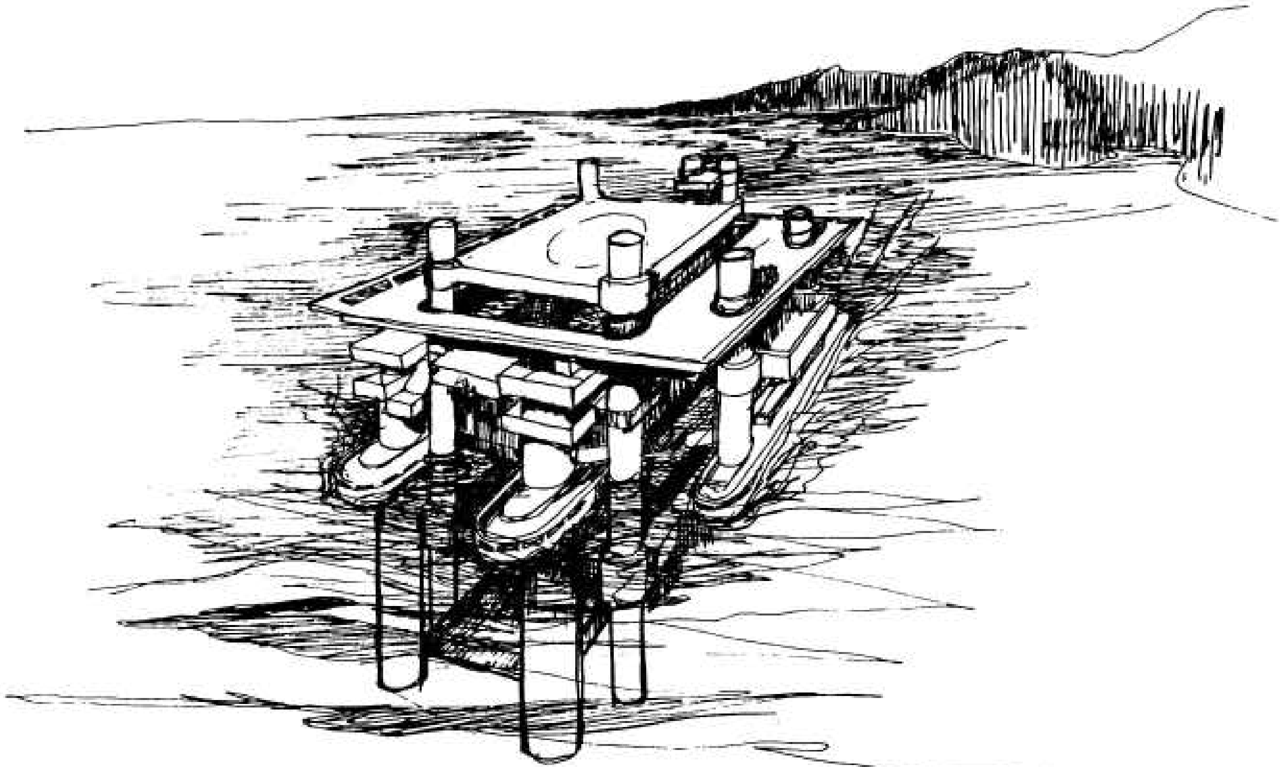
IV. PORT FUNCTION AND MOVEMENT USING OSMOTIC WATER PUMPS

Building the port with the natural processes described becomes a symphony of water movements. The evaporative pump used as vertical port caissons, which has more saline water in it, can accrete and thicken its mineral walls most rapidly using mineral salts. The vertically moving water of different temperatures and salinity can do a number of things. It can flood or sink to evacuate the water from an area for work to be done so it will float and can move away on the water's surface. Once the port facility is built it continues to utilize these natural processes and water movement for various functions. For instance, consider a dry dock facility.

Drydocks:

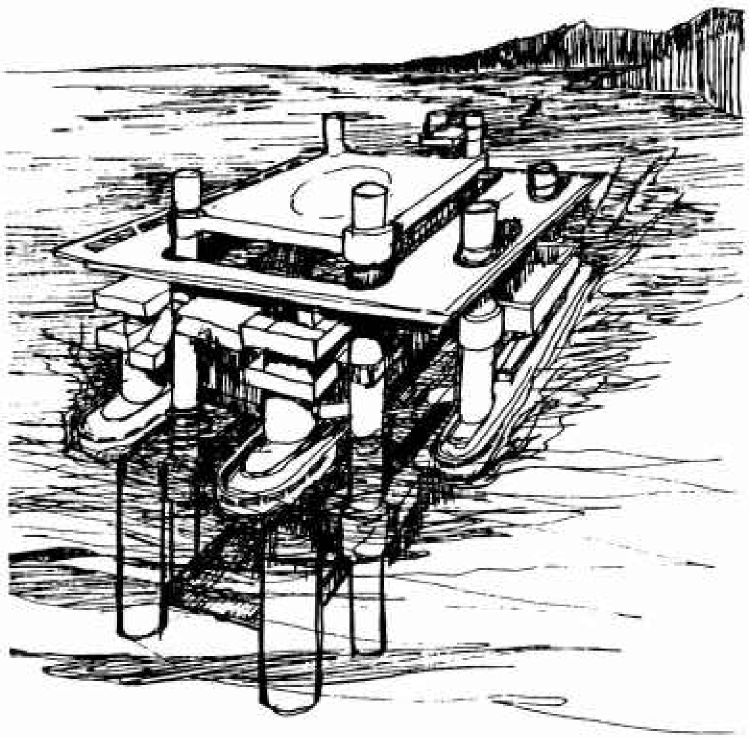
The ship can be floated into one of these vertical evaporative saline water pumps when the water is at its maximum, overflowing (due to freshwater drawn in to dilute the saline water). To leave the ship drydocked, the water can be evacuated by gravity, or an osmotic pump is used for the dock. Evacuation is accomplished by side membranes which allow this fresh water to move out into the sea water, which it will do, trying to stabilize the concentration gradient. It should be noted that in a boat-shaped facility a two ton ship can float in as little water as a centimeter between the ship and the dry dock. Two types of water pump placed in a siamese fashion can interact across a membrane to produce desired water levels while generating power. For instance, the osmotic pump can discharge water into the more saline water in the evaporative pump. The same principle can operate via the vapor pressure connection even though the pumps are not proximate.

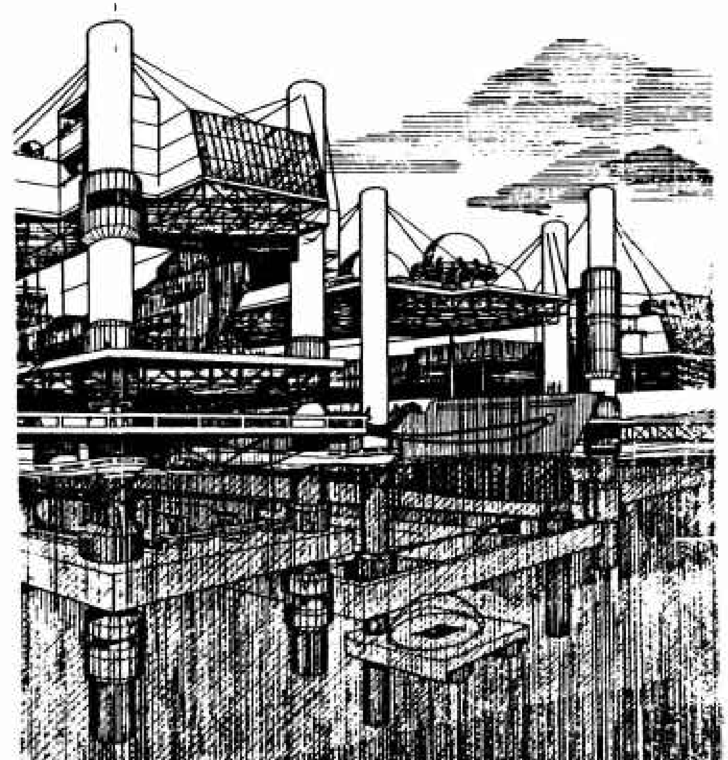




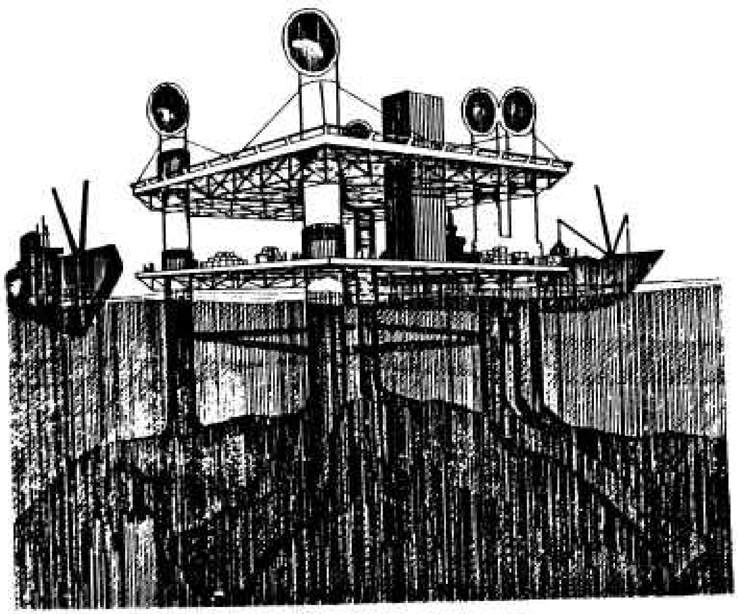
Mobile port:

A floating port can be a semisubmersible whose motion up and down in relation to the sea is determined by water movement in the caissons due to the natural process water pumps. This capability is desirable for moving the facility like a ship. Also individual decks of the port can move vertically due to water pumping action although in a separate but related series of pumps. This allows for repairing, servicing or offloading at heights most convenient for the ship's height and door, deck, ramps, etc., locations. Also ships may be floated beneath a deck for repair or gravity pumping of oil. And finally a drydock type facility on the mobile port may have yet another independent capability to move up and down.



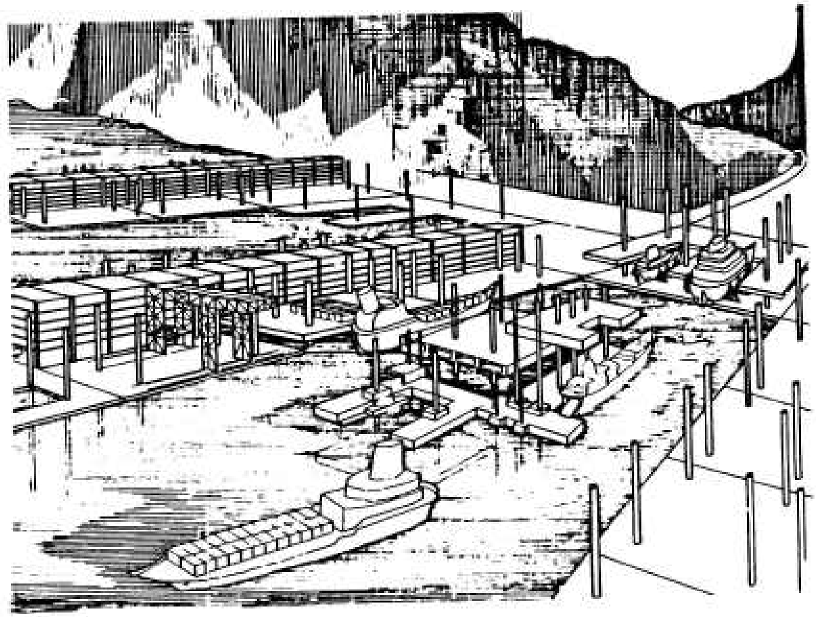


The locational requirement for these pumps to operate dictates further where the various pumps are employed. For instance, in a submersible port, the evaporative pump has to stick out in the air to function, the osmotic pump must go down quite a ways into the ocean and the OTEC pump has to be long enough for significant temperature differences. (Flexible bottom attachments may be required.)



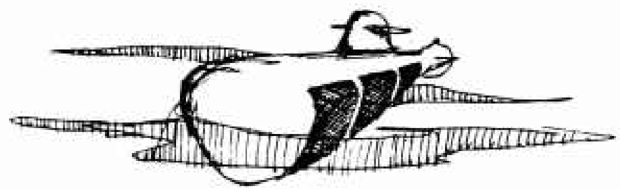
Stationary ports:

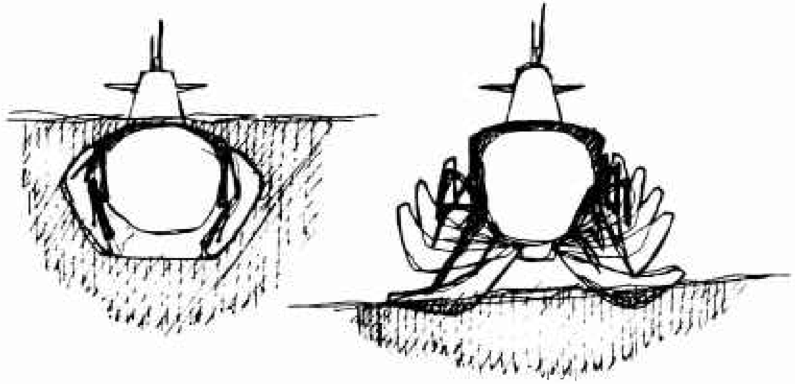
A stationary port is usually used for long term repairs, offloading of cargo and equipment, etc. The need for cranes, roll-on/roll-off facilities is acute. Cranes lift huge weights and transport them a short distance. Roll-on/roll-off roads have to relate the ship's height to the land's height. Both of these problems can be addressed by hydraulics. The stationary port can move and adjust vertically and in separate portions as does the mobile port. Lifting huge weights of containers and equipment can be handled by a hydraulic crane barge, but instead of lifting it pushes up with water.



Submarine theory or truly mobile ports:

A submarine can descend by taking on water to increase its mass. Blowing the water back out with compressed air decreases the mass for ascension. In order for the submarine to be stable while submerged, the density of the seawater must increase with depth at that level. If the submarine then moves upward slightly, a net downward force returns it to the previous depth. If it moves downward, the net force is upward. The density depends inversely on the water temperature and directly on the salinity, both of which decrease with depth. Between 25 and 200m in depth, a submarine can find several layers in which the temperature decreases rapidly enough with depth to offset the decrease in salinity and thus to provide stability."

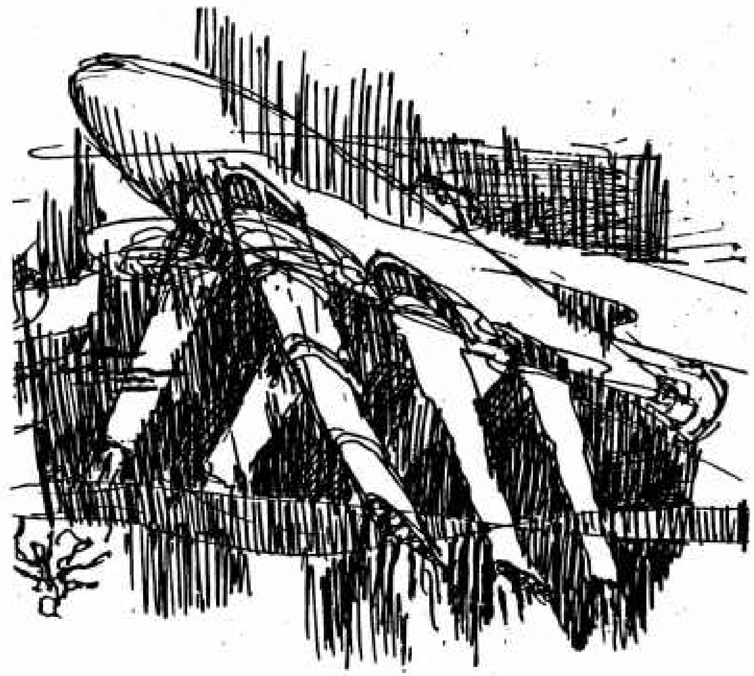




The submerging is dependent upon the relation of air to water. The amount of air has to balance the weight of the object for it to remain buoyant.

The water let into the tank can be ordinary seawater flooding the tanks or it can be fresh or more saline water of various temperatures to fine tune the stability of the vessel. These variations of temperatures and densities can be accomplished with the osmotic and temperature relationships described earlier.

The submarine can be raised out of the water for repair, etc. on fold out perimeter tanks. The submarine body is then pushed up, clear of the water, by hydraulic telescoping extenders from the floating tanks.

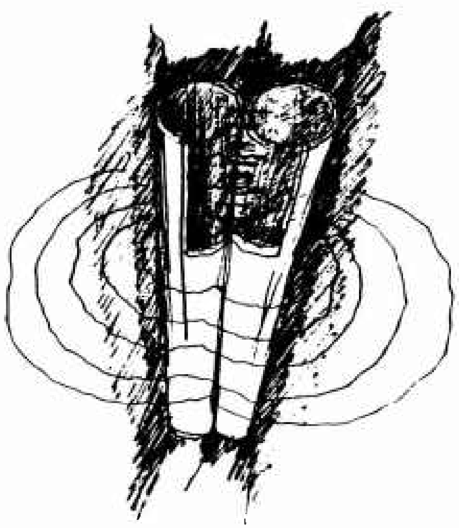


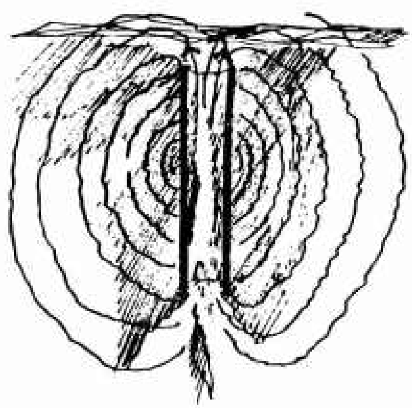
Sensing and transmitting:

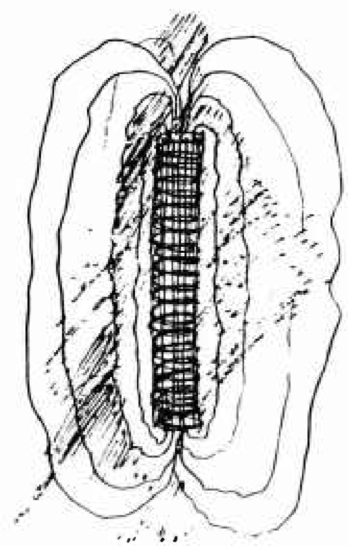
The impulse generated by the "nerve" like process gives information both about the state of the on-going process itself and also information transmitted from an environmental sensor. Also the vertical motion with a certain density level will to some degree interrupt the density stratification of the sea and thus alter the production of the electro-magnetic field within and below the sea; thus producing a detectable signal.

It is also known that the progression of time harmonic plane water waves (such as tidal waves) through the density stratified rotating electrically conducting seas over a stratified conducting earth and under a non-conducting atmosphere, produces an electromagnetic field within, above, and below the sea.[15] Thus the theory of oceanic vertical electrical field antennas is possible, which allows measurement of east-west deep-ocean fluid motion by electro-magnetic means.

Calcium and salts electrodeposited through use of an electrical current will build the structure. Not only does the calcium have peizoelectric properties for sensing and repairing its own structure, but the metal armature could be a ferromagnetic material. A polarizing magnetic field could be provided by winding the coil, carrying the current (which does the electric depositioning) around this ferromagnetic element, thus a magnetostrictive transducer is created. The structures and artifacts so made could then be electrical transmitters. Perhaps more importantly, the signal propogation system is also the container of the signal and transits it without loss in a directional mode -- this linear system is made relatively inexpensively from naturally occurring calcium by electricity which is also generated naturally.

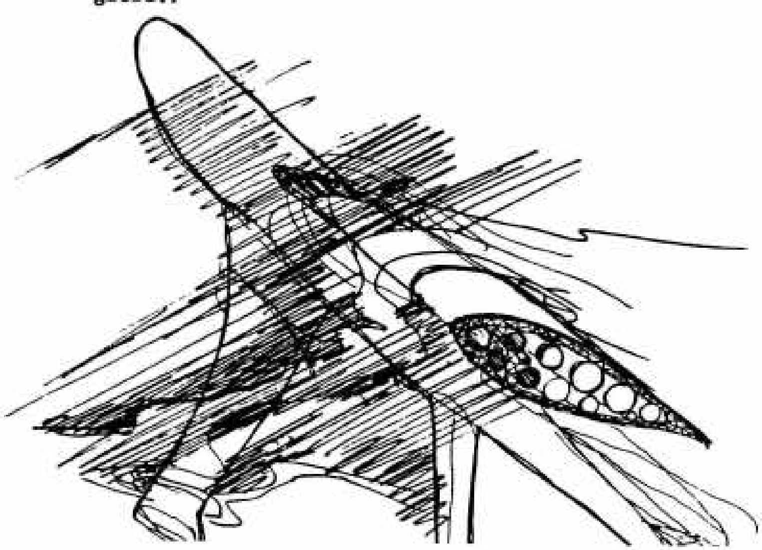






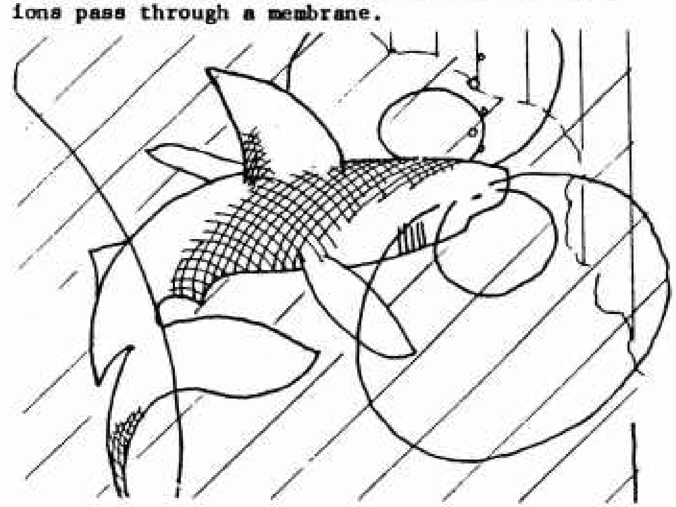
Sharks use this horizontal component of the earth's magnetic field. They produce direct current low-frequency voltage gradients in water which mainly stem from potential differences at their skin-water interfaces. By swimming to the east for instance, the shark generates -- according to Faraday's law -- an internal induced electromagnetic force which gives rise to electrical current that flows through the moving fish and loops back through the stationary (relatively) environment. When the fish turns north or south, the potentials vanish, when the fish turns west, potentials of opposite polarity are induced.[16]

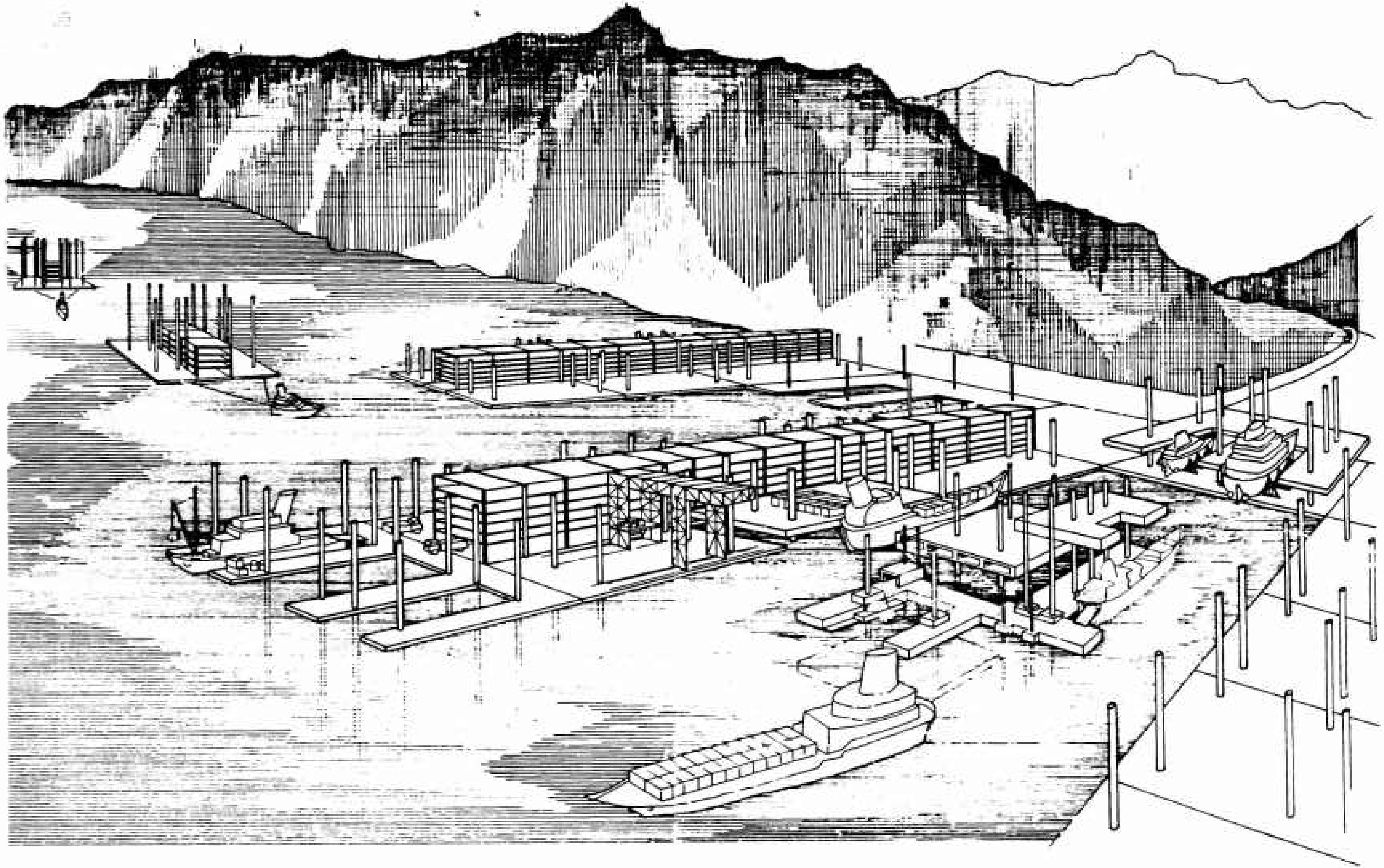
The generation of an internally induced electromagnetic force which gives rise to an electrical current that flows through the moving fish and loops back through the stationary environment is a form of active, electro-orientation because it generates the very field it detects. (Also through interaction with the vertical component of the earth's magnetic field the fish also induce motional electric fields parallel to their transverse body ones. Thus they may determine the magnetic latitude of their position on the globe.)



Just as in our own nerves we generate voltage and current directly by diffusion of ions across permselective membranes separating the concentrated and diluted solutions so an underwater vessel in seawater can produce a voltage and current by the same process. (Several membranes separating alternate concentrate and dilute solutions will produce more energy.) The voltage and current produced by ions moving through a membrane can add to the strength of the internal electromagnetic force as needed for orientation purposes, electrical camouflage, or as a transmitter of long range waves. If the movements of this vessel across the earth's magnetic fields, i.e. density stratification, are rhythmic enough it will produce an internal electromagnetic force which gives rise to electrical current that flows through the moving submersible and loops back through the stationary environment.

The submarine can also be made of metal electrodes accreted out of seawater minerals. The minerals provide some electronic camouflage. The submarine can generate its own geomagnetic field via the current carrying wire wrap around itself, by the interruption of the earth's natural geomagnetic field via interrupting the salinity stratification, or by the production of electrical current when ions pass through a membrane.





V. COUNTERCURRENT EXCHANGE AND MULTIPLIERS ADD SPEED AND POWER TO PUMP

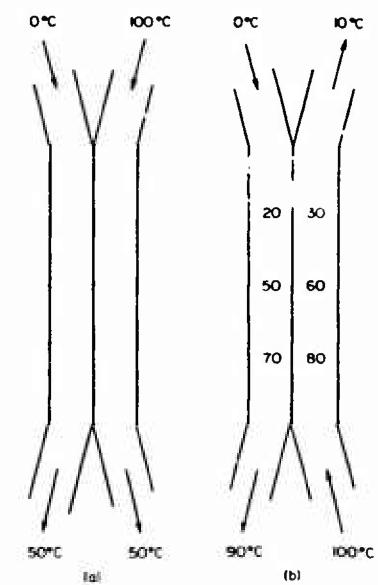
Countercurrent exchanges or multipliers can transfer or concentrate gases, ions - salts, calcium and heat at an increased rate or amount of concentration.

Building ports with structural materials found in the ocean environment, notably calcium and ice, the requirement to raise and lower ships and cargo with sufficient strength, and the peculiar opportunities for building ports offered by desert and cold climate, all are improved by the use of countercurrent exchange design.

The physical principles:

A "hairpin countercurrent osmotic multiplier" system acts to create a gradient in osmotic concentration within the kidney by active transport of sodium ions. This is a very efficient way of producing concentrated urine.

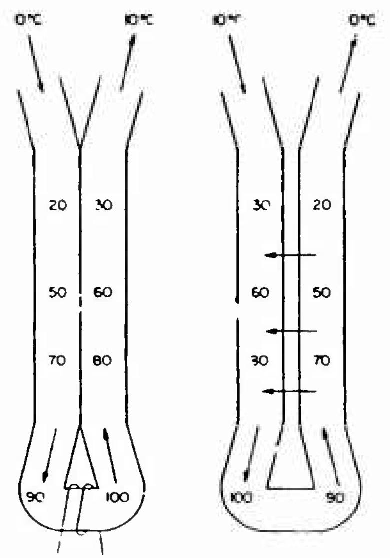
"The ability of these loops of the kidney to set up and maintain a large gradient of osmotic concentration through the kidney depends on countercurrent systems, the properties of which are perhaps easiest to visualize in terms of heat flow. Consider first of all a heat-exchanger in which two streams of water flow in parallel and at the same rate. If the hot water entering is at 100°C and the cold water at 0°C, in the first part of the exchanger there will be a difference of temperature of 100°C so heat will flow rapidly. The temperatures of the two streams will rapidly approach each other, but the 'cold' stream can never reach a temperature above 50°C, however little resistance to heat flow there is between the two streams (see drawing). If the direction of flow in one of the streams is reversed, the situation is rather different. The cold water entering receives heat from water that has already been cooled further along the exchanger so the rate of flow of heat and the rate of warming are initially less than before. However the cold stream is always flowing towards hotter water, so that heat continues to flow throughout the length of the exchanger. At a particular rate of flow for a particular exchanger, there would be a difference of temperature of 10°C at all points. In this case, the initially hot water would leave at 10°C and the initially cold water at 90°C (see drawing). This 'countercurrent' heat-exchanger is thus much more efficient in terms of transporting heat from the hot water to



Heat exchangers. A. Parallel. B. Countercurrent.

the cold than the parallel flow one is. If the resistance to flow of heat between the two streams is reduced (or if the rate of flow of water is reduced, so that less heat needs to flow for the same temperature change) the temperature difference between the two streams at any point will be reduced so making the exchanger more efficient.

Now consider a heater applied to a water pipe. If 10 calories are applied for each ml of water which is flowing through, then a temperature rise of 10°C will be produced. If the inlet and outlet of the heater are connected to a heat exchanger like that of the countercurrent one, to form the



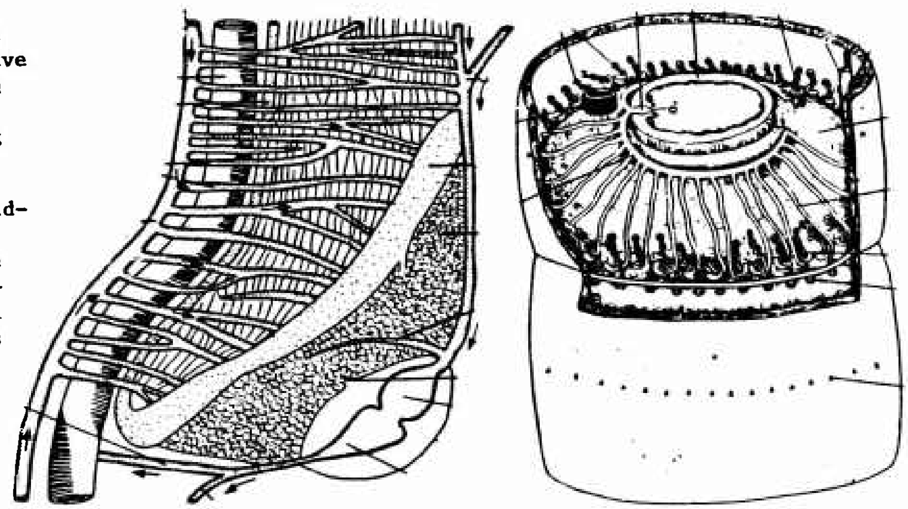
Countercurrent heat multipliers

hairpin arrangement in the countercurrent heat multiplier (see drawings), then initially the water leaving the system will be only very slightly warmer than that entering, so that less heat is leaving than is being put in, and heat accumulates in the system. Heat will continue to be retained and the temperature to rise until all the heat being applied is leaving, i.e. when the water leaving is 10°C hotter than that entering. When this state of affairs is reached the situation in the heat exchanger will be exactly as in the countercurrent heat exchanger (see drawing), so that the temperature of the water entering the 'hot' side of the exchanger will be at 100°C. In this way the exchanger has acted as a 'countercurrent multiplier' and increased a temperature difference of 10°C across the heater (and across the exchanger at any one point) to a temperature difference of 100°C between its ends. The illustration also shows up another property of countercurrent exchangers which is in effect to 'insulate' the ends from each other. In this case 90% of the heat in the water leaving the heater is returned to it, so that the temperature gradient can be maintained with only 10% of the heat which would be necessary without the exchanger.

Temperature gradients similar to those in the drawing would be maintained if instead of heat being supplied by a heater at the tip of the 'hairpin', heat was transferred by some process from the ascending stream to the descending stream of the heat exchanger. If the rate of heat transfer was such as to maintain a 10°C difference in temperature between the two streams at all levels, then the only difference from the drawing would be that the ascending limb would now be colder instead of warmer, but the overall temperature difference between the ends

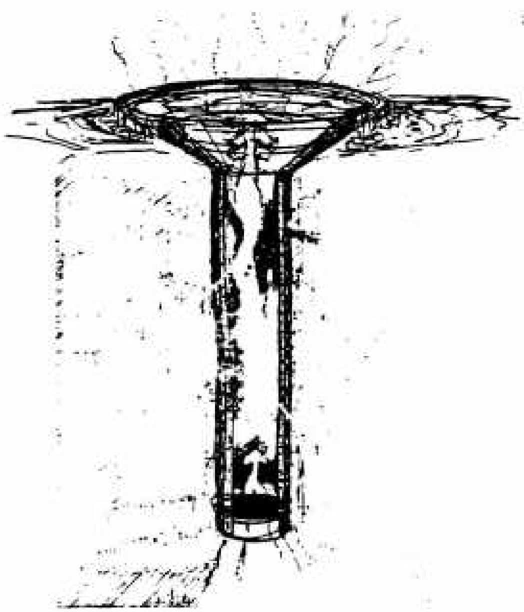
would be the same. (To make the situation exactly the same, it is necessary to cool the water by 10° C as it goes round the hairpin bend. It is also necessary to have the water entering at 10° C instead of 0° C. Apart from anything else it would freeze otherwise). Such an arrangement would then be very similar to the loops of Henle with the substitution of 'osmotic concentration' for 'heat content.'

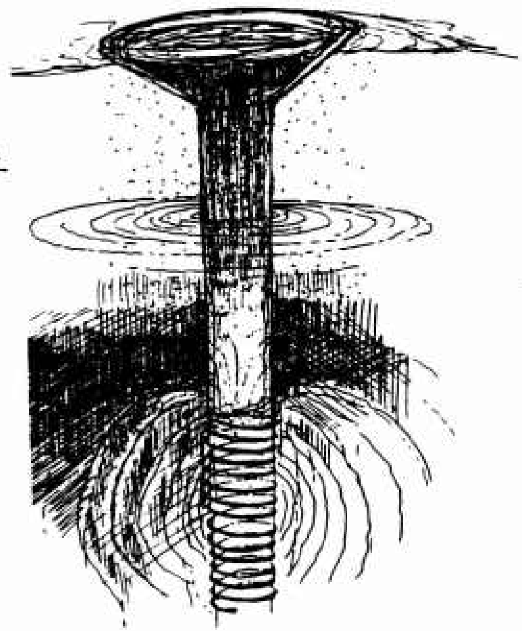
The real action of the loops of Henle in the kidney depends on the fact that the descending limbs of the loops are freely permeable to sodium (and chloride) ions and possibly water, while the ascending limbs are impermeable to water and actively transport sodium ions from the tubular fluid into the extracellular fluid, with chloride ions passively following due to the potential which this creates - as in the proximal convoluted tubules. The mechanism by which sodium ions are transported is probably the same as that which operates in the proximal convoluted tubules. However, here it is capable of moving sodium ions against a much larger gradient, because the passive permeability of the ascending limbs to sodium and chloride ions is very much less than that of the proximal convoluted tubules. At all points along the ascending limbs the osmotic concentration of the tubular fluid is of the order of 200 $mmol^{-1}$ less than that of the extracellular fluid surrounding them. At each point, however, the fluid is the descending limb rapidly equilibrates with the extracellular fluid because of the high permeability. Thus, at every level, sodium chloride will in effect be transported from the ascending limbs of the loops to the ascending limbs of the loops to the descending limbs, thus holding sodium chloride in the medulla in the same way as heat is held at the bottom of the system in the drawing. In this way, the fluid in the descending limbs is continually increasing in osmotic concentration as it flows towards the tip of the papilla while that in the ascending limbs is continually falling is osmotic pressure as it flows back again towards the cortex. It can be seen that the concentration difference between the extracellular fluid in the renal cortex and the extracellular fluid surrounding the tips of the loops of Henle can be much greater than the concentration difference between the fluid in the ascending limb and the extracellular fluid at any one point. Also, the greater the length of the loops of Henle, the greater will be the concentration difference which they can produce. Continuous activity of the ascending limbs will be required to maintain this gradient, since it will tend to be dissipated by diffusion within the extracellular fluid, by the blood circulating through the medulla and also by entry of water from the collecting ducts.[17]

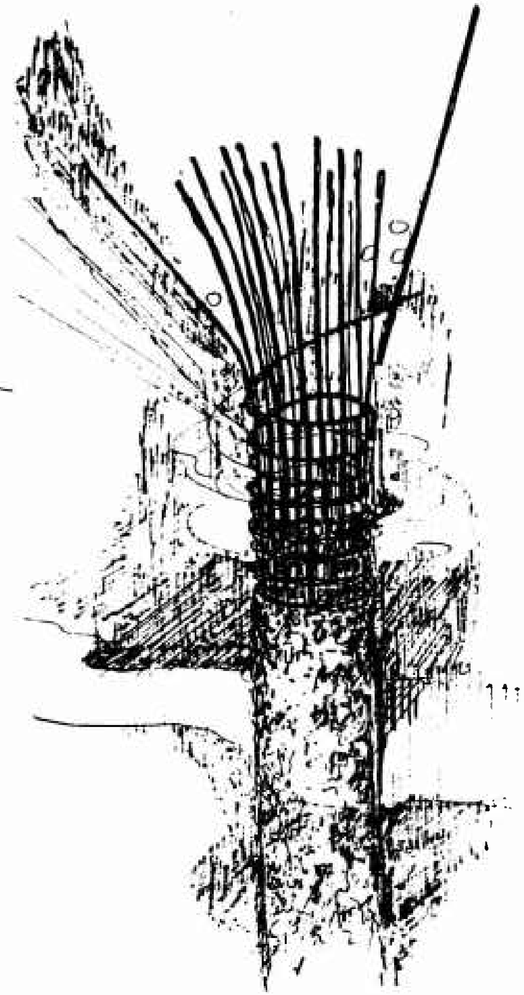


Ion Exchange (salts and minerals)

The closed system saline pump design which contains more mineral salts than normal seawater improves the deposition rate and the self repair process. After accretion is accomplished this closed system is given over to signal generation and pumping water upward.



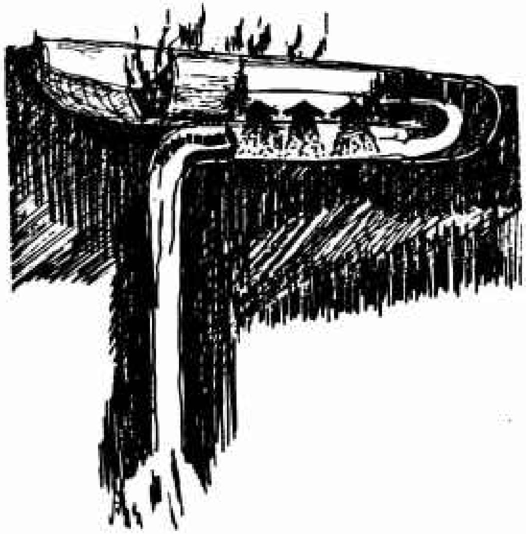


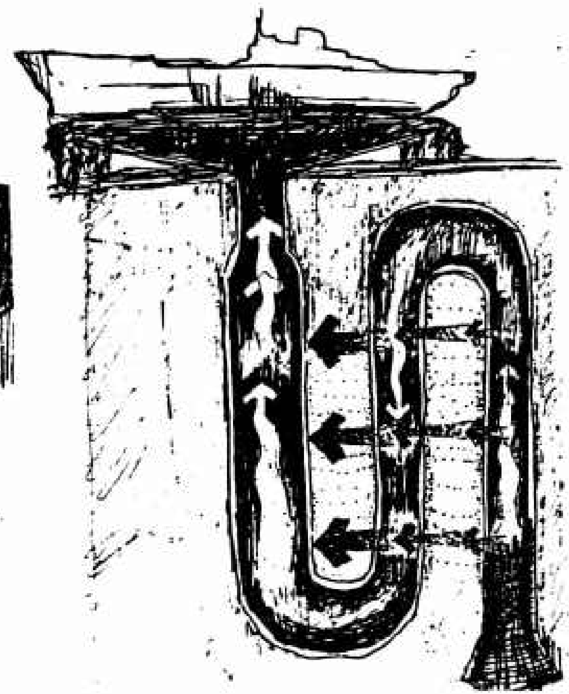


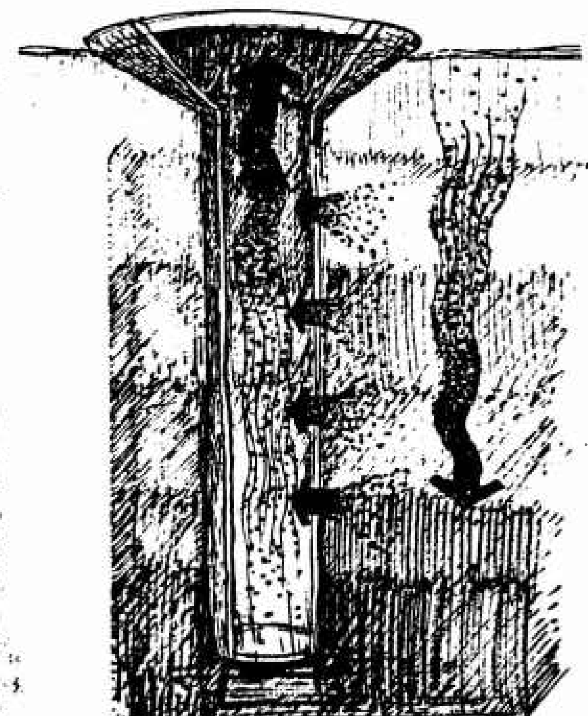
By designing the closed system into a series of loops the ionic concentration (or heat rate) can be multiplied more; it becomes a countercurrent concentration multiplier. This horizontal loop is near the surface where greatest concentration occurs in the closed evaporative system.

This increased salt concentration greatly enhances the lifting or pumping power, and the strength of impulses when the exchange with fresher water occurs across membranes in the closed system, and the ability to accrete the structure in the first phase.

But by redesigning this closed system into the natural countercurrent exchanger it is, the exchange rate can be enhanced. The salinity quantity is highest in the deeper parts of the ocean while the upward movement of water caused by evaporation (or freezing in cold areas) causes a reversed situation. The more saline water is at the top surface. Membranes along the vertical length of the tubes would allow for countercurrent exchange. There is the increased pressure due to the speed of the incoming less saline water, thus improving the pumping speed, and the faster movement of ions across the membrane generates stronger impulses.



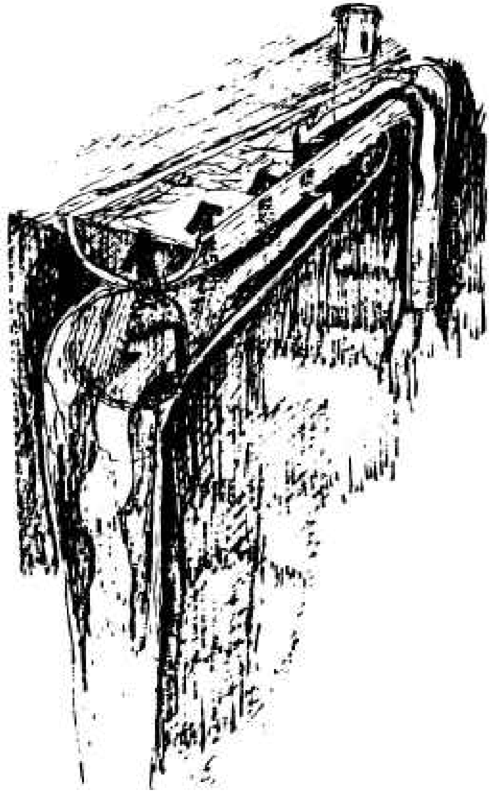


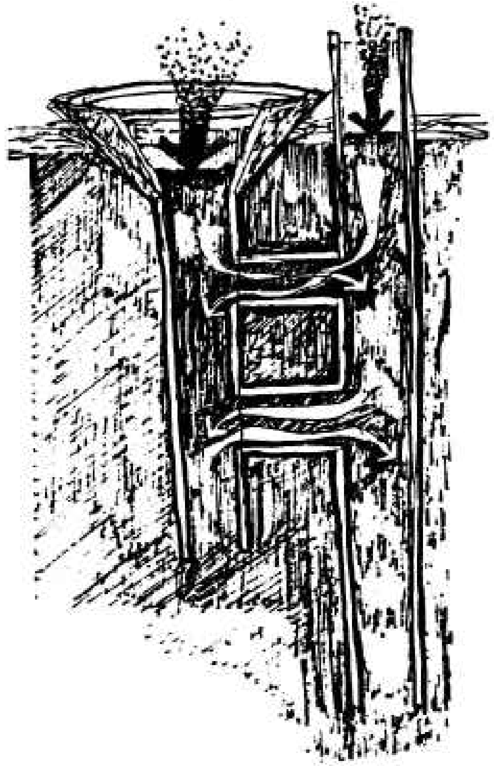


That exchange of salinity gradients between the enclosed pipe and the open ocean can be greatly enhanced if one pipe containing the evaporated more saline water is connected with the pressure osmotic pipe bringing up fresh water instead of the more saline ocean water. The ions can pass longitudinally between the pipes across membranes. It is a countercurrent gradient multiplier which uses the extreme of fresh water and very saline water, thus producing the greatest speed and power of exchange.

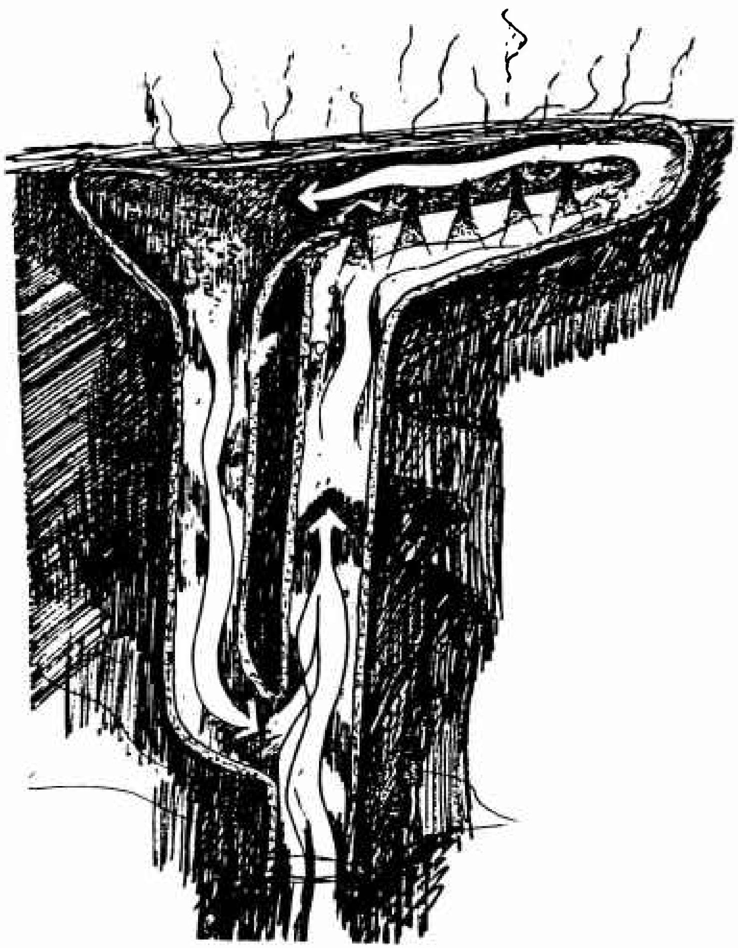
These designs of a countercurrent multiplier for increased salinity and a countercurrent exchanger for increased gradient difference serve to increase the speed and power of the water pumps. And while the structure is accreting because only the mineral and salinity multiplier is in operation, it greatly speeds up the accretion process.

The ability to slow down the speed of the pumps and the lifting power or to lower them is accomplished by shunts or by reversing the osmotic flow with some electrical power.

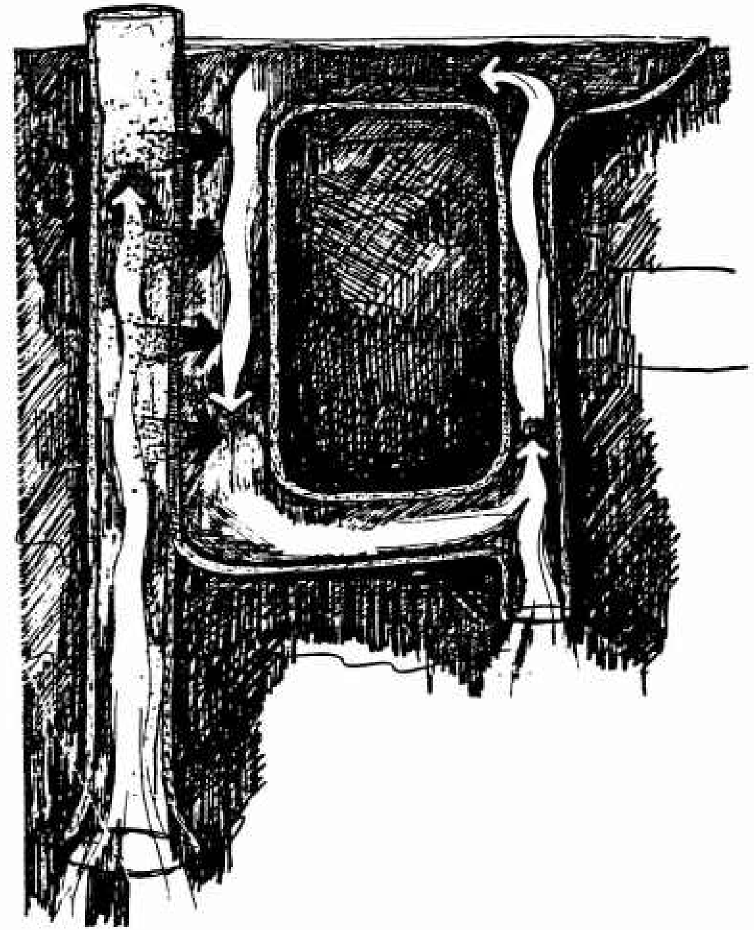




The ability of the countercurrent multiplier to increase the salinity level depends upon internal recycling of this saline water in the multiplier.



The fresh water rising in the osmotic pump due to pressure will be exchanged with this concentrated saline water on its way downward to recycle in the multiplier. Thus two extremes of concentration differences are coming at each other and exchanging from opposite directions, ensuring maximum concentration exchange.



Ports with countercurrent exchangers and multipliers

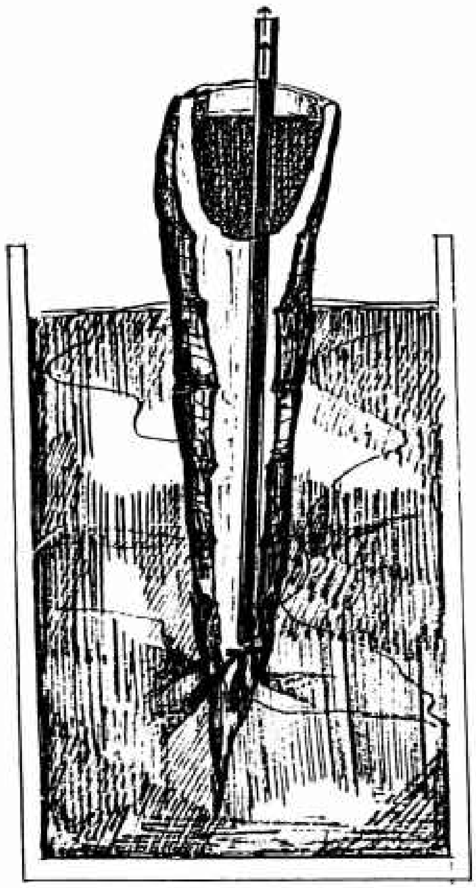
The sequence of events is that the port columns accrete quickly while the seawater mineral multiplier is working alone, which increases the mineral and saline content of the seawater. Once that step is completed, the exchanger is turned on (in addition to the multiplier) for the pumping action to increase speed and power. At this time a phase change material (think of jello, or ice hardening) is added to the hollow column and solidifies: the strong pumping action lifts these up into place, and in the most interesting cases, the slip formed columns remain in the accreted columns, acting as hydraulic lifters for the whole building or portions of it.

Along with the idea of the ice slip formed post-pushed up and out by the water pumps, a package concept is possible which is made partly out of cellulose with say a concentration of sugar, salt or something else lining the insides of that cellulose surface. The water enters through the cellulose unpacking the package and sending it out of the water as directed. Perhaps large container slip boxes are melted apart from their dissolvable ties or driven apart by these small pumping actions and then the smaller panels enter a directed path to shore.

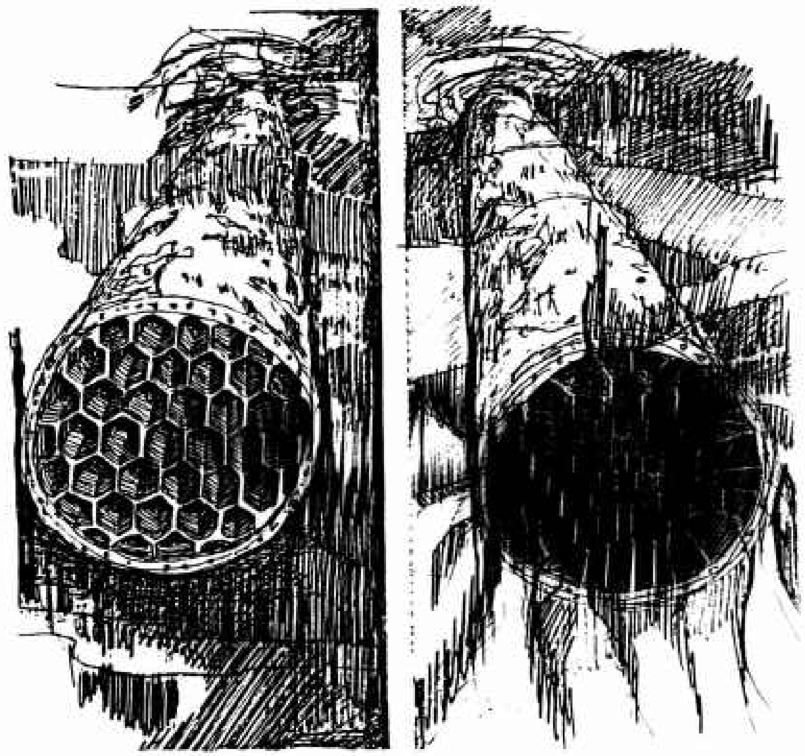
In cold regions the cellulose may then be used as part of the ice building process. It is needed to strengthen the ice resistance to erosion.

Membranes:

The membranes may be seen as too expensive, undurable and not available in large enough sizes. Cellulose can be used to separate ionic solutions. For instance, a carrot submerged in fresh water but containing sugar or saline water in a volume in its top will draw water up.

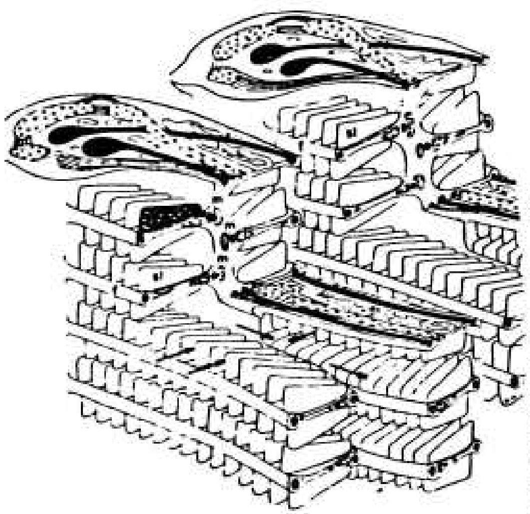


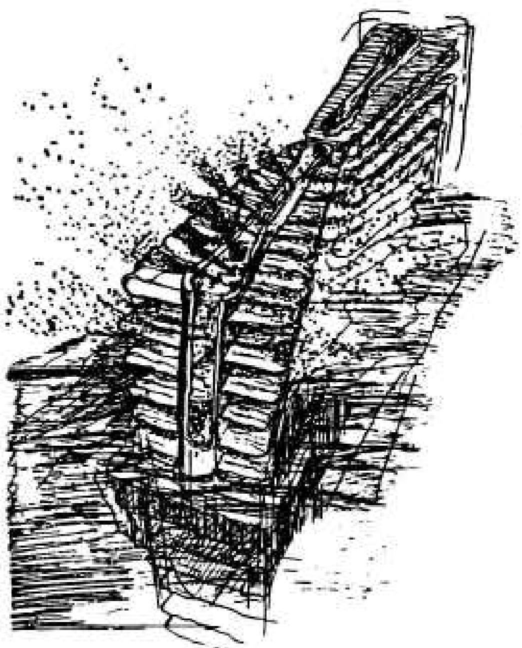
Collagen, one of the active ingredients in tendons and muscles, "will expand in contact with fresh water and contract in contact with salt water or visa versa. This behavior is typical for any unreinforced, not highly crosslinked ion-exchange resin." Such a device was built in 1966 by Katchasky. It took a long time for the collagen to expand and contract. Cellulose strikes ones as the simpler choice.

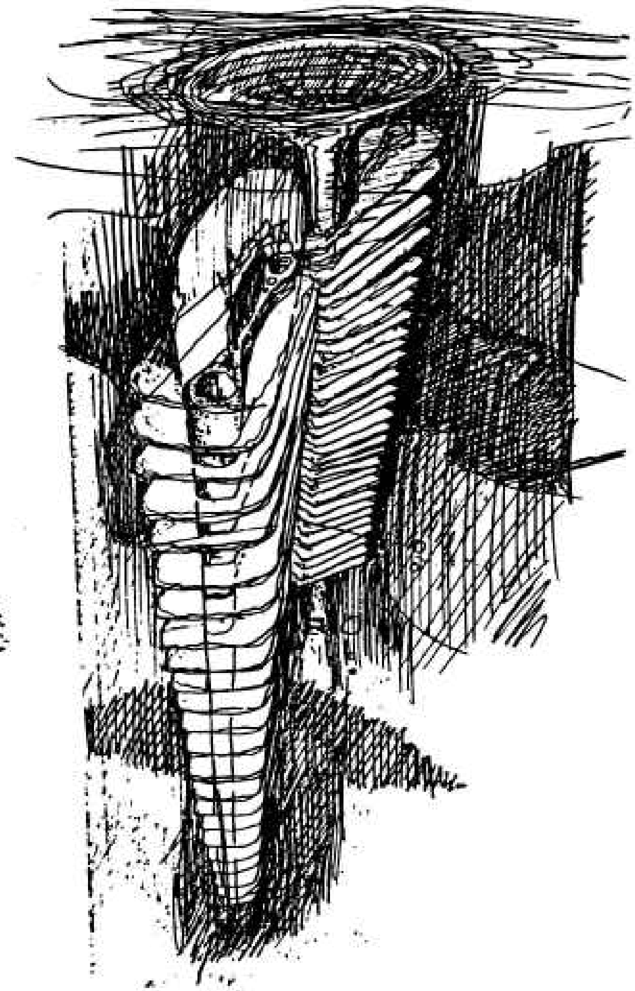


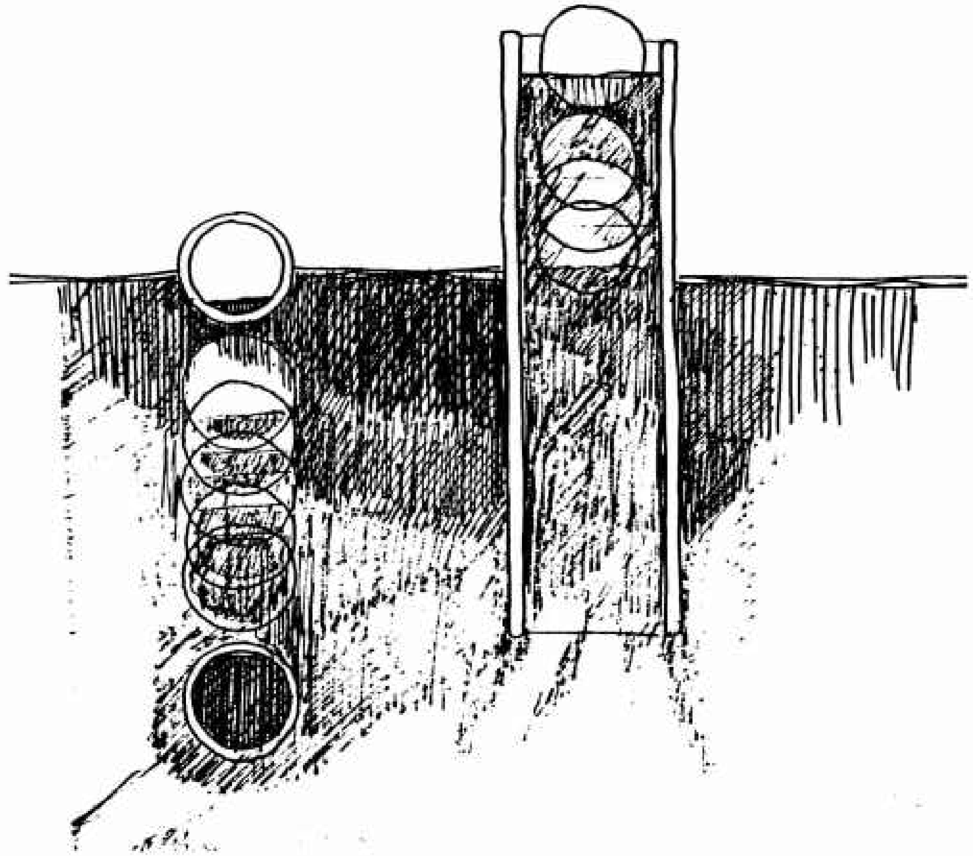
Gas Exchanges

Countercurrent exchangers and multipliers work with gases as well as ions. The evaporative water pumps have gill-like fin membranes which when exposed to the air can absorb air into the saltwater, producing bouyancy. This bouyancy or air gradient in the water provides a way of raising the whole port or pipe structures out of the water or submerging them.



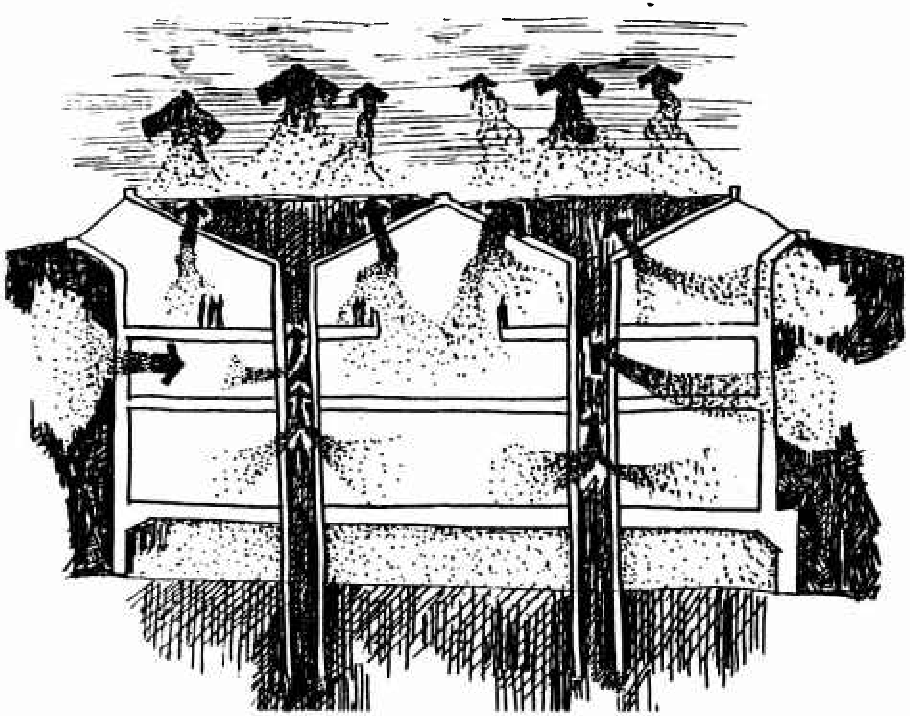


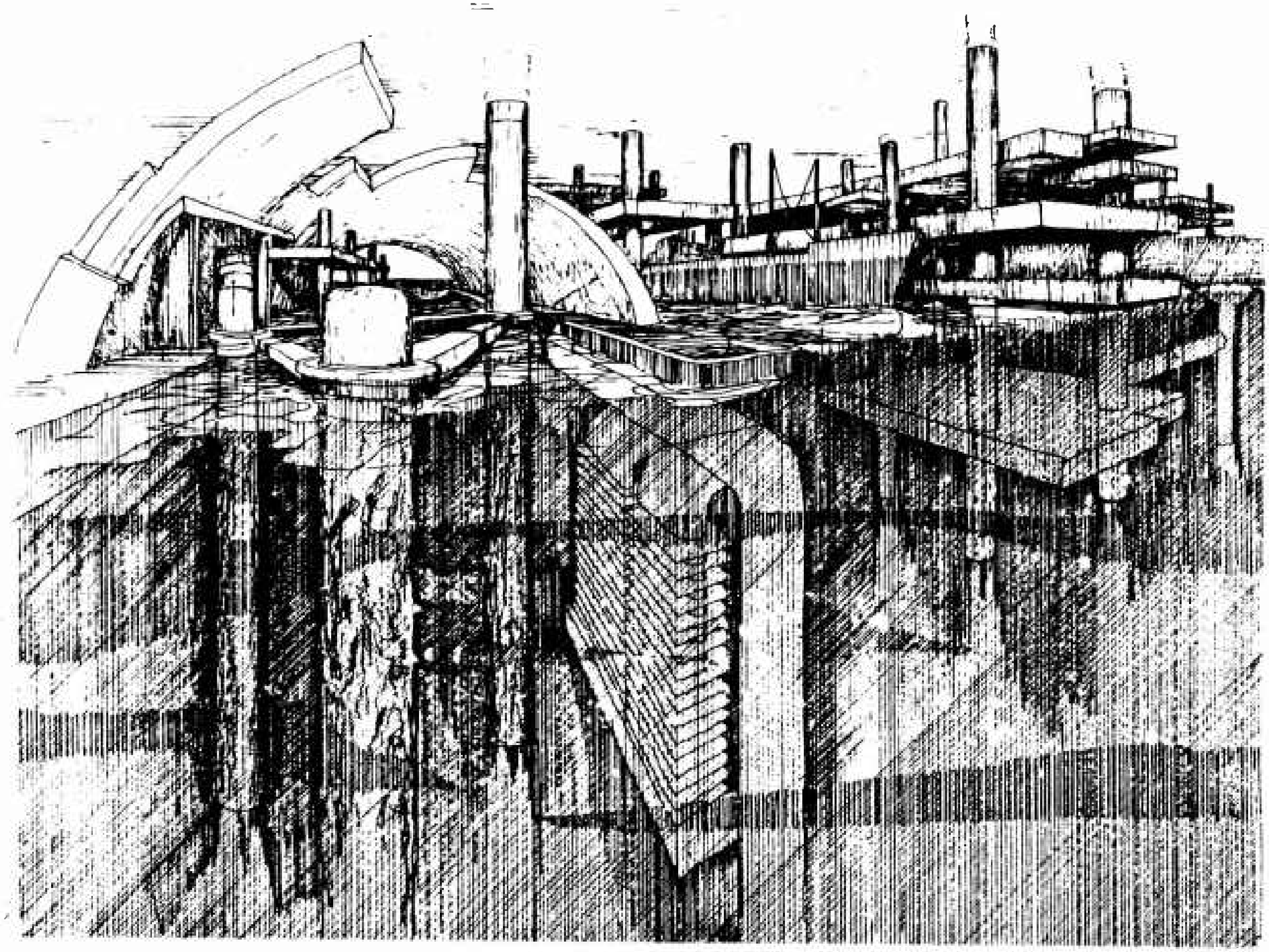




Heat Exchanges

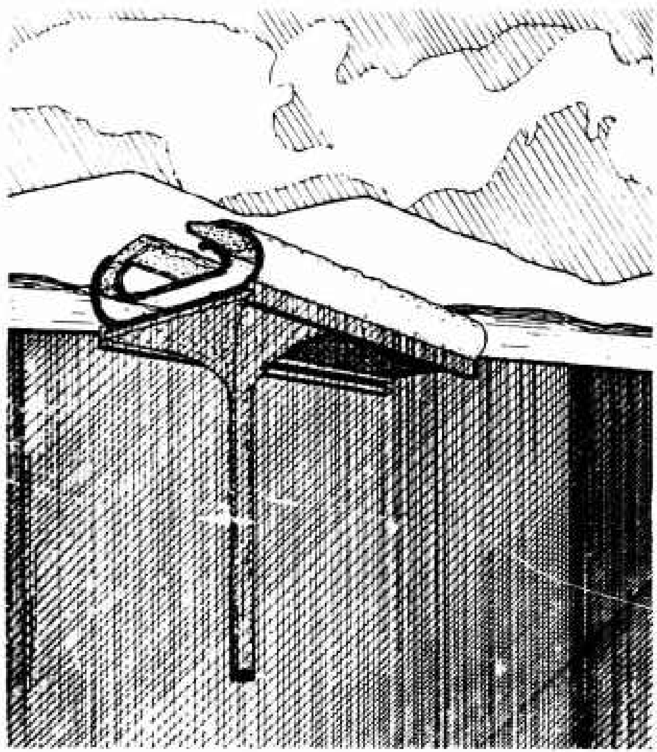
In the ocean in hot climates the deep water is the colder. As the water moves upward in the closed pump described it brings this colder water into contact with warmer surface water allowing for a heat exchange which can generate energy. Similarly in cold climates the cooler water is on top which is brought into contact with the warmer deep water when it is piped up, allowing for heat exchange also. In the desert land locations where cool ground water is pumped up through the earth to the hot surface temperatures, energy producing heat exchange also occurs.

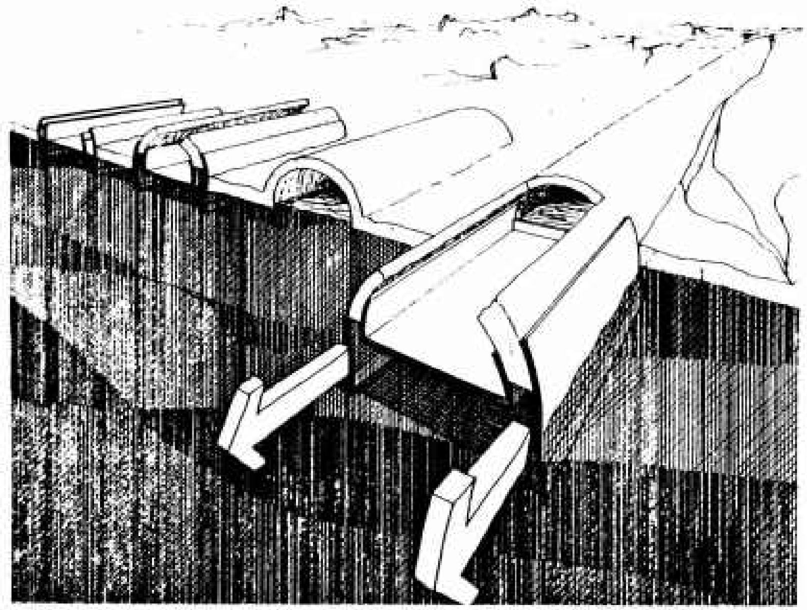


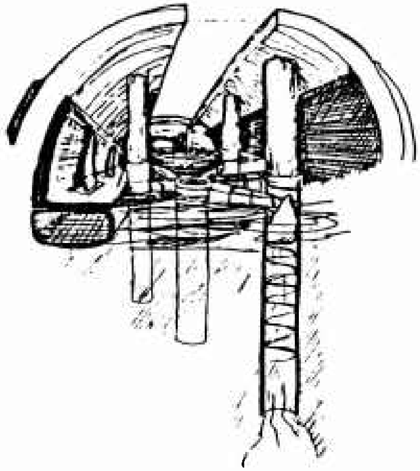


VI. PORTS IN COLD REGIONS

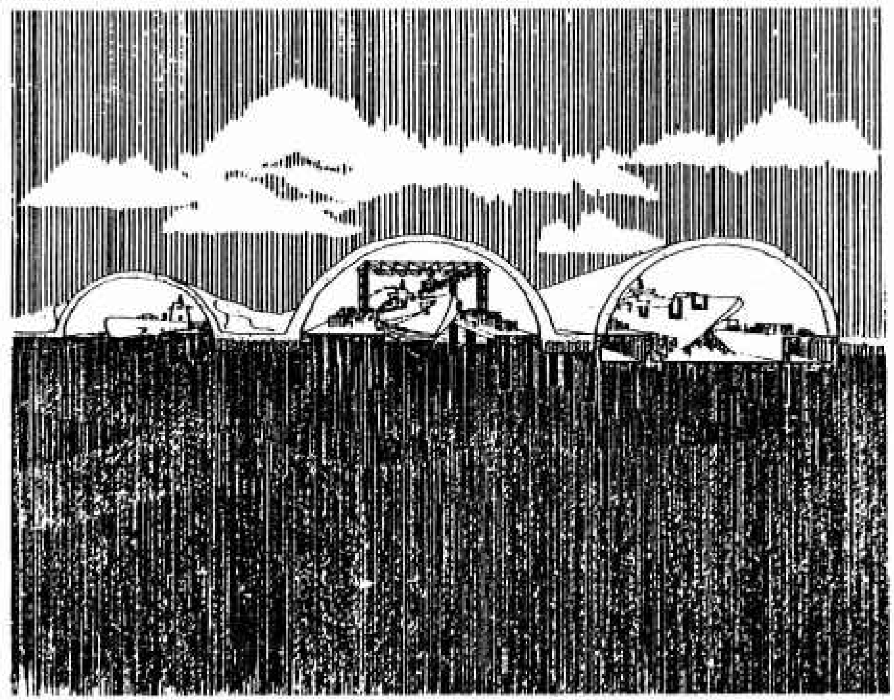
The evaporative process which produces saline water in an enclosed volume and attracts fresh-water to dilute it,is replaced by freezing in cold climates. It too leaves behind more saline water. The ice produced, a building material, is continually pushed upward by the incoming water. Arch shapes can then close on each other as they are pushed out, forming a domed ice enclosure. The freshwater driven upwards by the osmotic pump configuration will freeze too. This ice is a building material.







In the case of the evaporation pump the colder air freezes the seawater producing ice and a salty brine, in the osmotic pump the freshwater pushed into the pipe will freeze because freshwater freezes at a higher temperature while the saltwater is still a liquid. Ice tends to melt and weaken after a time so it should be mixed with cellulite for greater strength and resistance to melting. (In World War II Churchill proposed making an aircraft carrier out of just such material.)

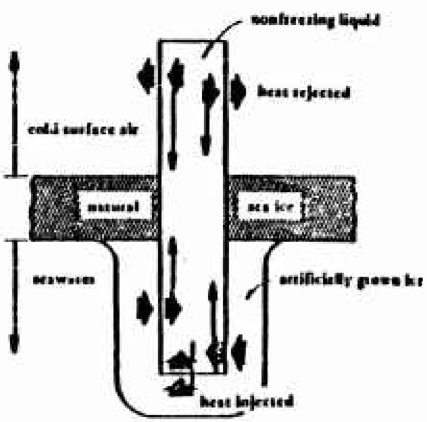


Thickening the ice sheet:

Some ice normally forms in winter on the water's surface. The cold air freezes the top water while the seawater remains warmer than the air. As the ice sheet forms, the ice acts to insulate the seawater below which keeps it at a relatively warm temperature, thus finally an additional ice growth is retarded.

A heat sink method for subsurface ice thickening based on the temperature differential of air and ice covered seawater was developed by CEL.

"This scheme accelerates ice growth at the underside of an existing ice sheet. Most simply, pipes with closed ends and containing a subfreezing refrigerant are installed through an ice sheet into the waters below, thereby promoting subsurface, radial ice growth. These pipes effectively short-circuit the insulating tendency of the ice sheet.



Liquid-convection ice-thickening device.

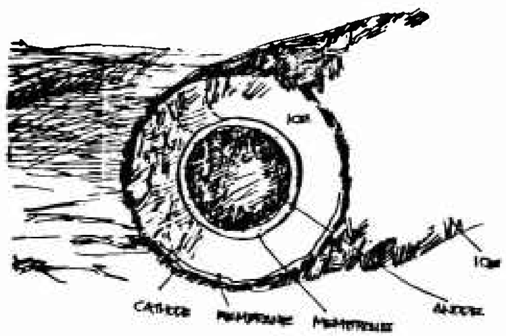
Heat transfer from seawater to ambient air is redirected by means of a natural convection recirculating cycle within the pipe: the heat of fusion is extracted from the seawater by the cold refrigerant to the colder atmosphere. The recirculating cycle is a result of density differences within the liquid refrigerant. Therefore, such a cooling device is irreversible, operating only during those periods when the ambient air is at a temperature lower than the subsurface seawater.[18]

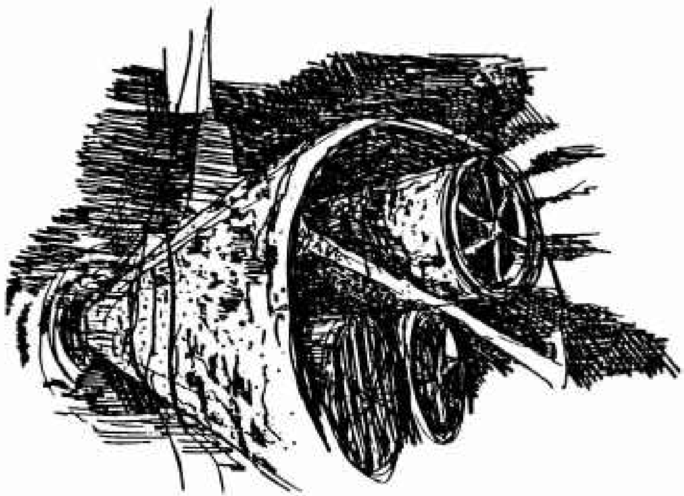
The self-powered heat exchanger is driven by temperature inversion and is called a "freezing cell" when used in polar application to thicken ice sheets. The heat exchanger could be replaced by the Hilsch-Rank vortex tube which can supercool the water.

In the simplest case of the hose nozzle a sh temperature transition between the hot body and the ice forming structure prevents ice sticking in the nozzle and this is provided by cold blocking insulation in the nozzle. A more developed extrusion nozzle will take the material, i.e., seawater, process it by osmosis or dialysis and extrude ice and mineral accretion tubes. The coolant in the nozzle provides a controlled chilling of the water to a solid state.

Another method for freezing water in the zones away from the surface is, simply, obtain freshwater and freeze it in the deep colder saltwater. This scheme utilizes the fact that saltwater is colder near the bottom and will cause freshwater to freeze. Ice freezes at $0^{o}C$ and saltwater freezes at -2^{o}. During the winter months seawater surrounding many polar locations, including the North Alaska Coast, is at the freezing point temperature* but the temperature of deeper seawater is fairly consistent year round. Therefore the ice stays frozen.

The simplest way of making an ice pipe with osmosis is to take two dialysis membranes facing out -- away from each other -- one for the inner wall of the pipes, one for the outer. The salt passes through the membranes and into the free-flowing seawater inside the pipe and outside it.



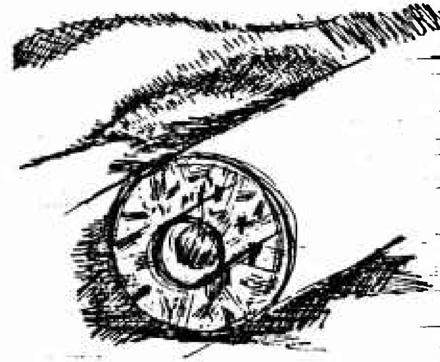


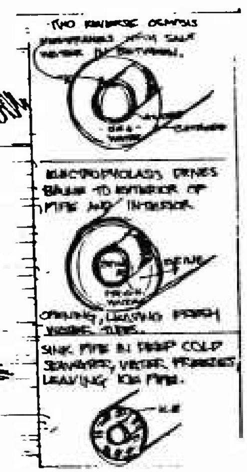
Mineral and ice pipe made through electrodialysis:

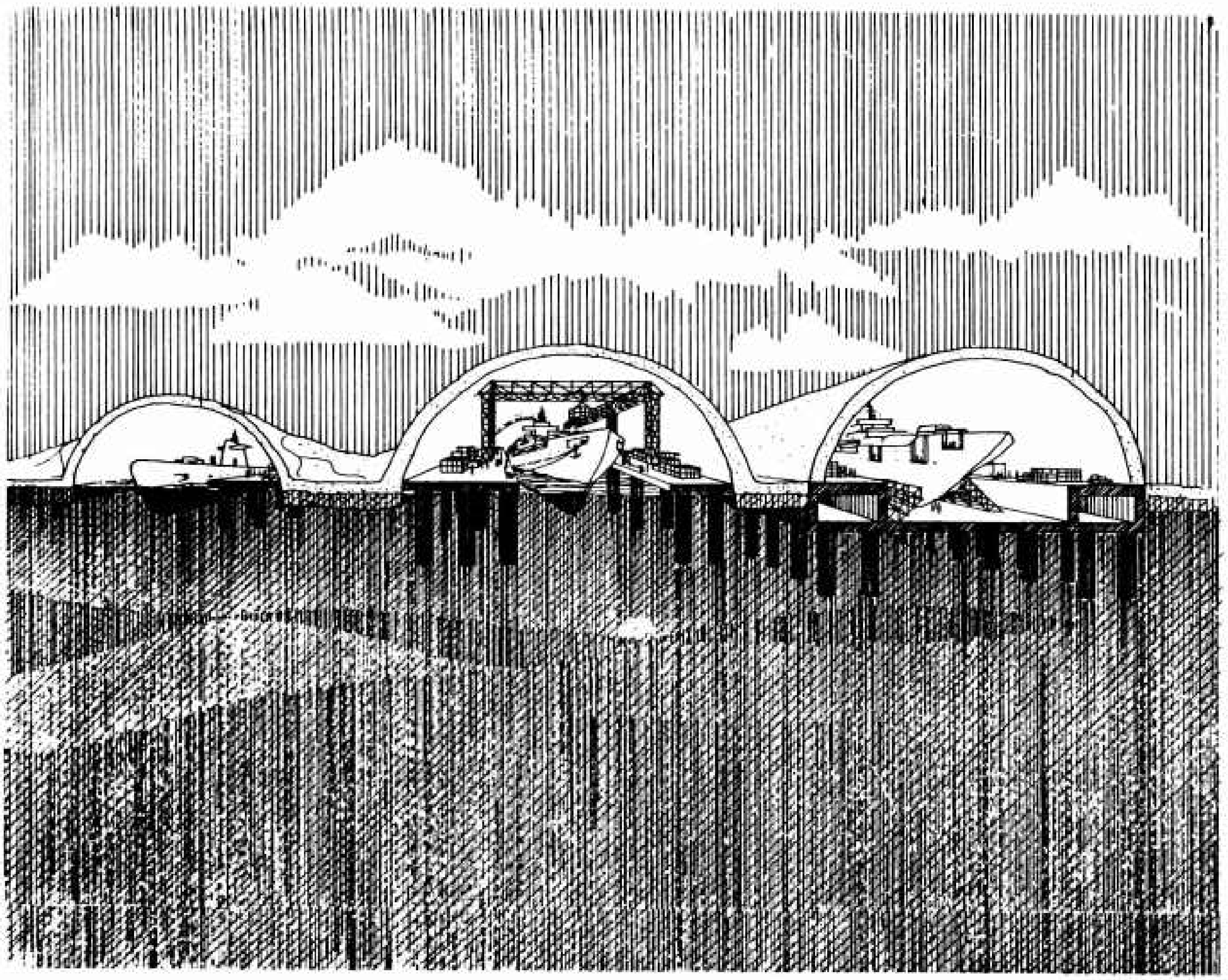
The accretion technology and freezing of desalinated water can be combined. The electrical current will accrete out the mineral ions on a charged surface as part of the electrodialysis driven by electric current which forces salt out through the membrane.

A wire mesh pipe with interior osmotic membranes tubes is hooked onto electrodes and submerged into seawater. The current produces an electrodialytic deposition of minerals on the exterior wire mesh, as the salt water contained in the pipe is pumped through the membrane forming a freshwater ice interior lining and discharging the brine through the pipe's interior. Or the process is reversed and the accreted pipe is inside the ice covering.

A pipe or cable covering on which ice is deposited in controlled amounts can vary its thermal and electrical insulating properties. Some cargo specific pipes like oil and gas pipelines have great thermal considerations.







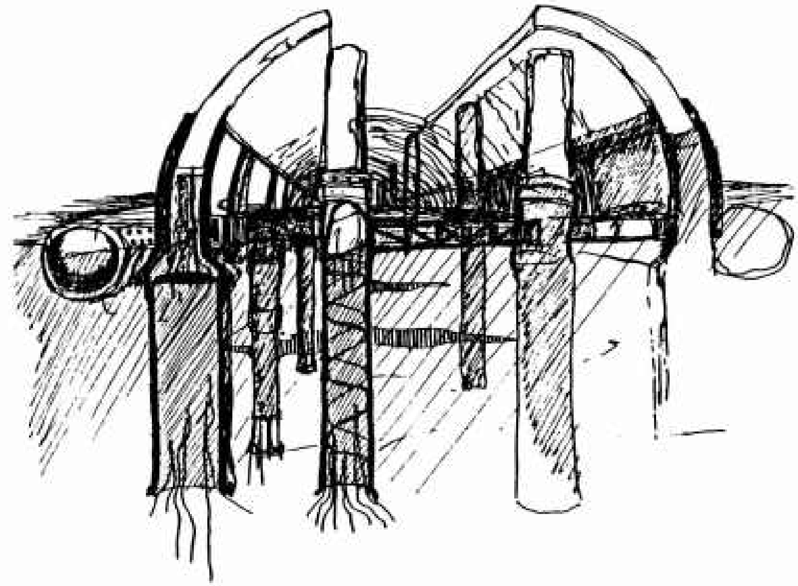
Ice ports:

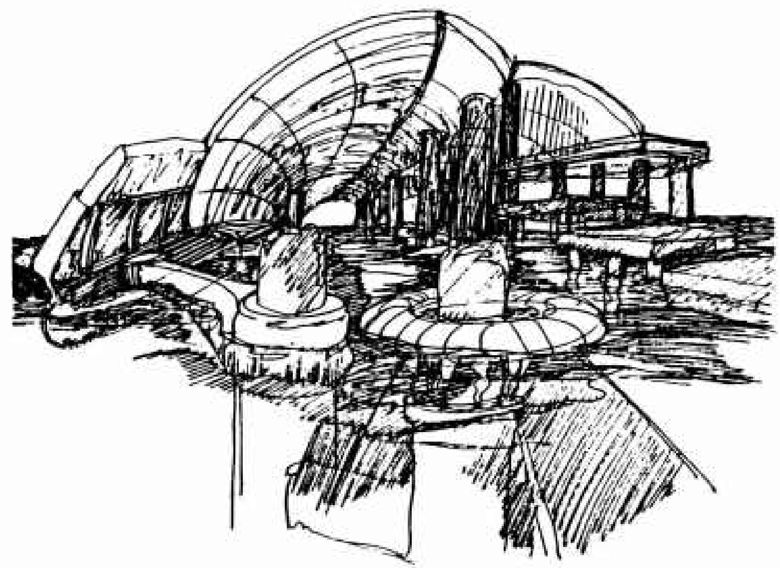
Floating port structures of ice can be made from the thickened ice sheet, the surface produced ice domes, structures from the "evaporation pump", ice columns pushed upwards from the "osmotic pump" and mineral and ice pipe "thermos bottles", hollow ones produced by electrodialysis or reverse osmosis for the ice pipes alone.

A building machine consisting of osmotic pumps ejecting their ice columns under the "evaporative pump" domes and horizontal elements is capable of constructing a 3-dimensional structure, i.e., port with many levels. The ice sheet may be thickened to attach the port, to make it permanent. Individual elements may be moved into place by the gases given off during the accretion process moving the already buoyant ice.

The behavior of the port is much like that of the other ones in warm climates made from minerals, that is, portions move up and down as water moves across membranes up into or out of the hollow chambers to create or reduce buoyancy. The creation of ice, which is more buoyant than freshwater and much more so that seawater, will cause rising of portions of the structure and its melting causes sinking. Melting can be caused by an inserted electrical wire, reversal of the action of a heat pump, warm air from the Hilsch-Rank vortex tibe, or warm seawater brought up by OTEC pipes.

A design for combining the way of building with behavioral motion up and down is as follows. In an enclosed area of seawater with semipermeable membranes and electrodes, wires begin accreting minerals for the structure — as this is done it leaves purer water which then begins to freeze

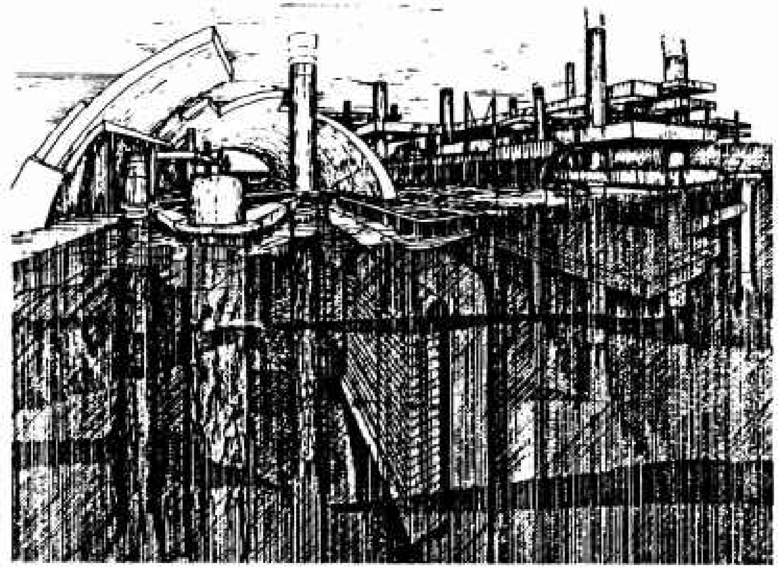


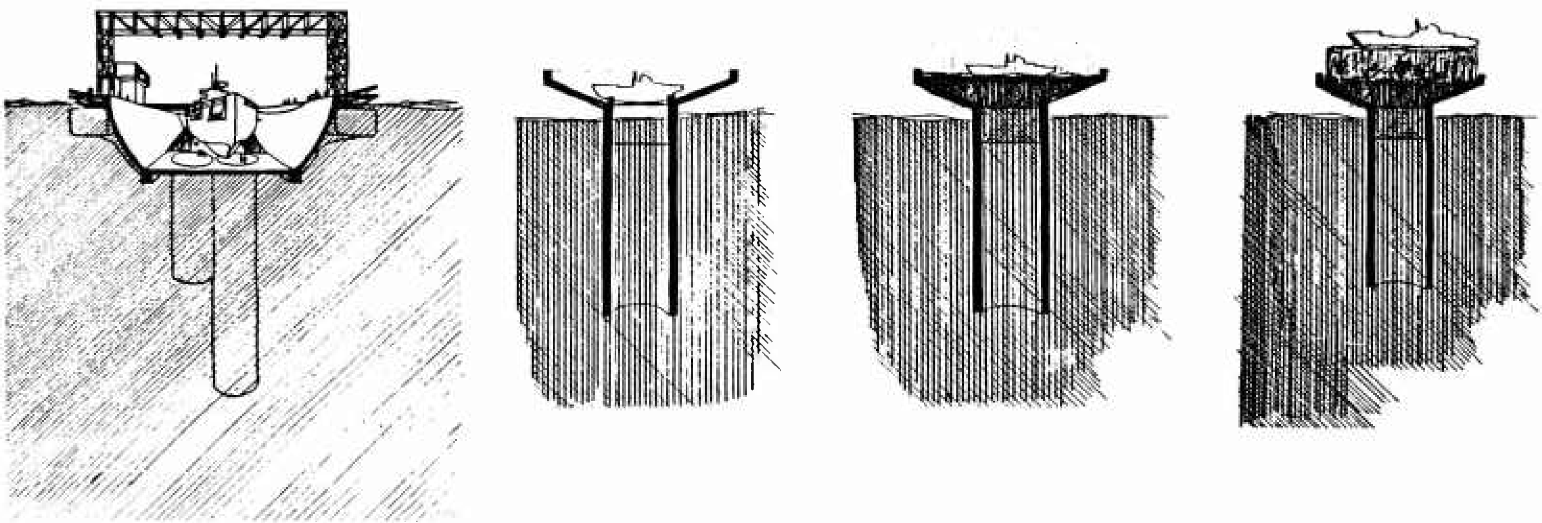


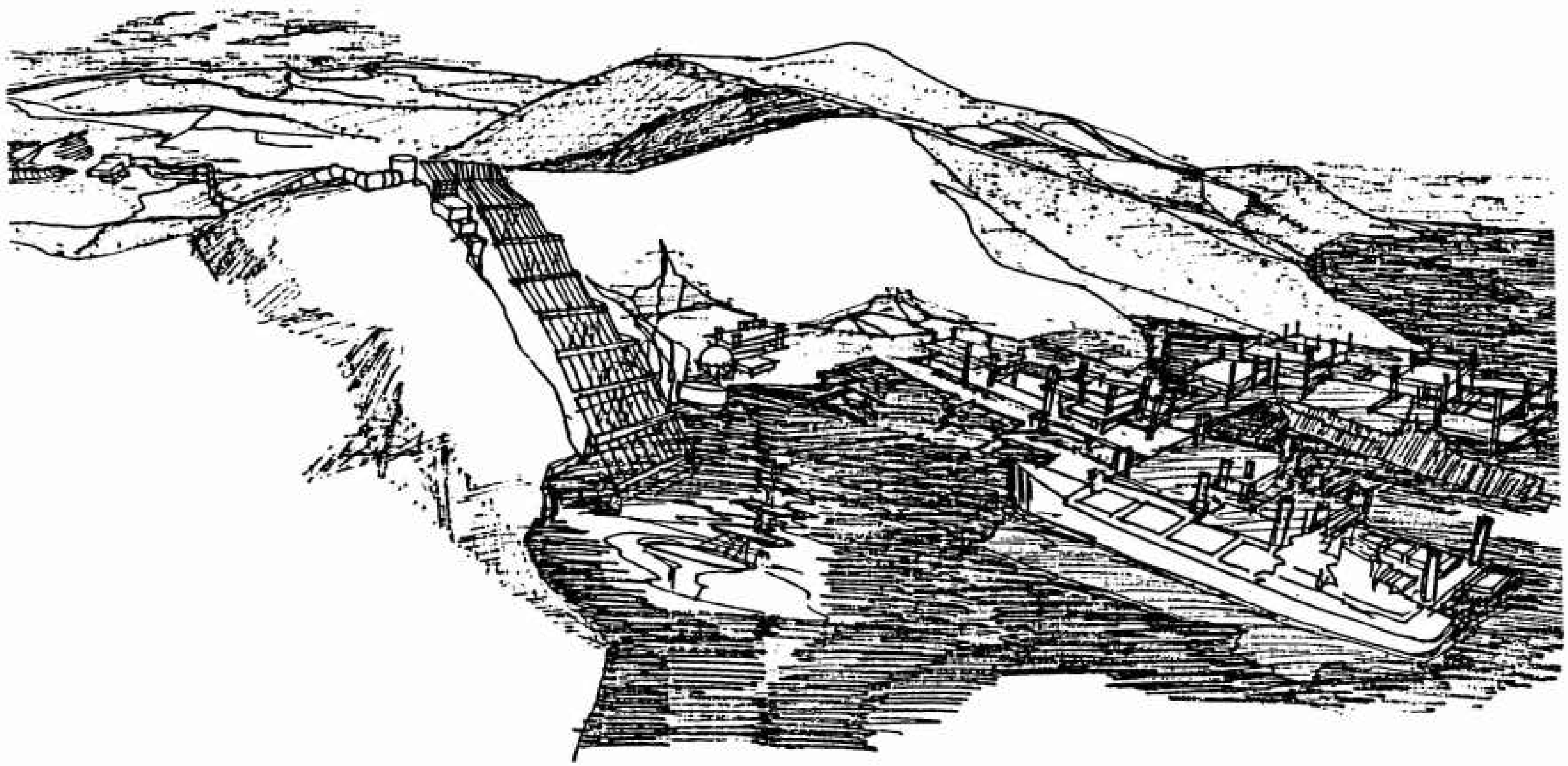
causing the caissons to become more buoyant. The osmotic pressure is outward (freshwater to more saline), causing further freezing. For less buoyancy either add heat to melt the ice or reverse the accretion process or allow the fresher but yet unfrozen water to flow out via gravity.

A drydock idea peculiar to cold climates is to slightly flood the dish form-fitted drydock and let this water freeze - expanding to lift the ship up out of water, or to let water in the pump freeze, expand and raise the ship directly.

These ice structures can be used as camouflaged submarine ports, mobile ports for all types of ships, and breakwaters. Also the pieces of buoyant ice formed underwater and then released, rise to the surface breaking up the energy of wave action. Even a submarine can use ice floats for rising in the water column.







VII. PORTS IN DESERT REGIONS

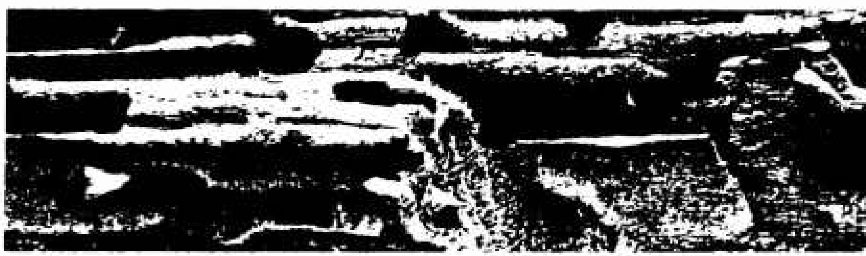
Deserts are characterized by lack of water or excessive evapotranspiration, brackish ground water, strong winds, diurnal temperature shifts and excessive heat.

A biogeophysical feedback system is in operation also. An increase in albedo or reflectivity resulting from a decrease in plant cover causes a decrease in rainfall. Thus any tendency for plant cover to decrease would be reinforced by a decrease in rainfall so causing more drought condition.

Desertified areas are those lands that have been made into deserts; often because of salinization of the land by improper irrigation, erosion of the land by wind and water, and human cutting of firewood, all of which eliminate vegetation and thus make it uninhabitable. Solutions would entail replanting, erosion control, increased ability of the soil and plants to retain water and moisture, careful use of water.

Ports in deserts having clay soil

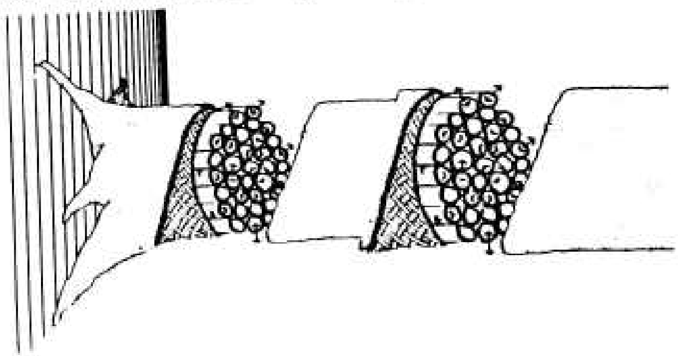
Coastal deserts have soil types of either clay salty soils or sandy soils. This focus is on those with clay salty soils. The hydrological characteristics of these soils are: the high level of the strongly mineralized groundwater, surface salinity, easy crystallization of salts and high degree of capillarity.[19]

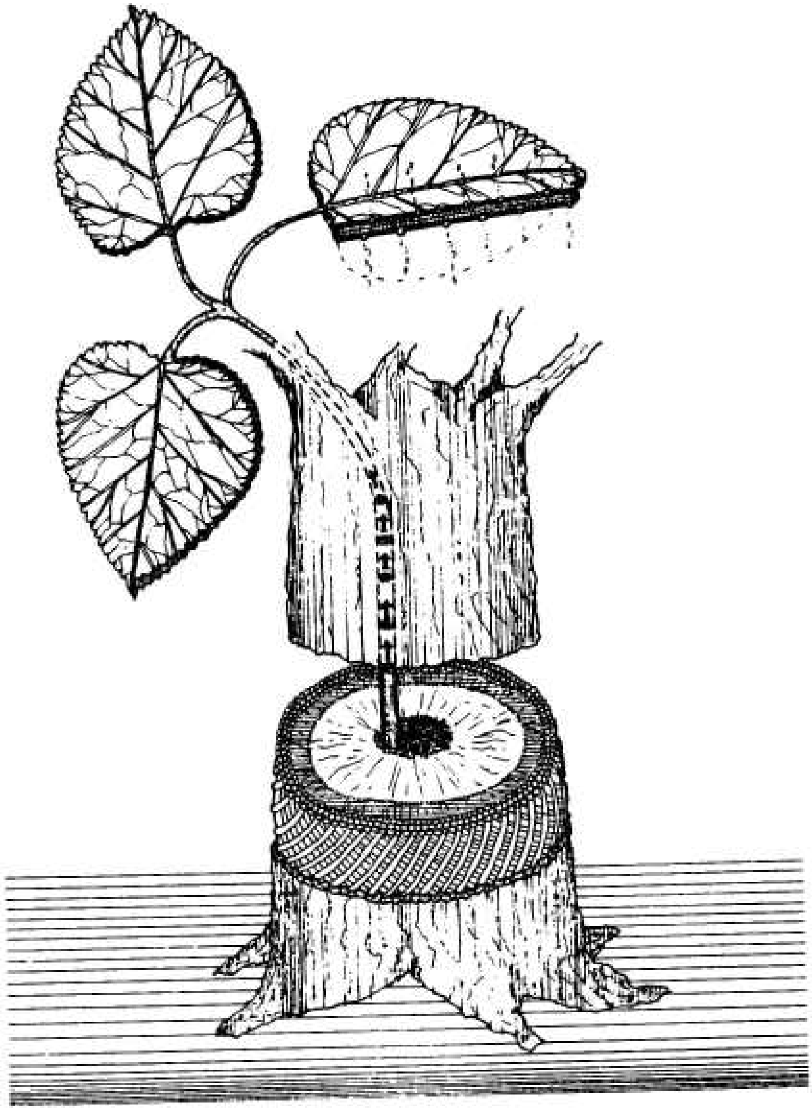


The method of reclamation for this type of desert is to lower the level of mineralized groundwater -- either by pumping or drainage ditches. This proposal looks at pumping. This reclamation means planting vegetation so a desert region or a drought area will have increased humidity in the lower atmosphere. As albedo increases, which is a result of decreasing plant cover, there is a decrease in rainfall. [28]

Trees as pumps

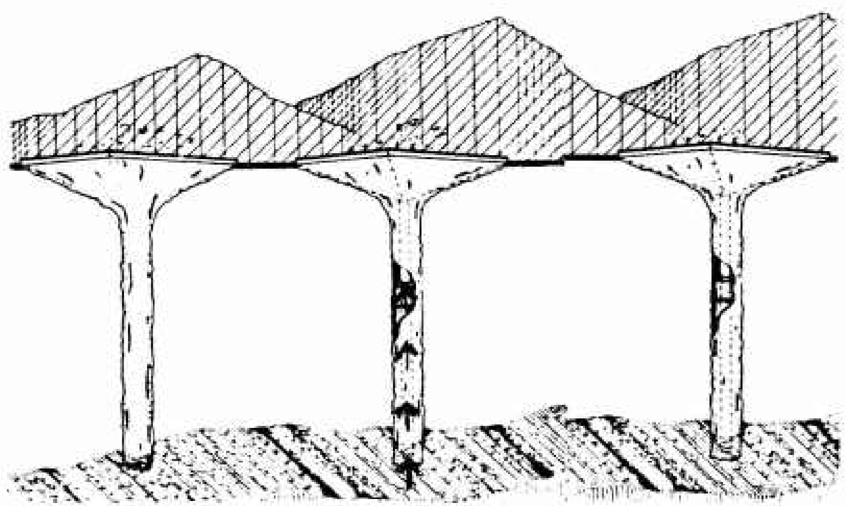
Trees evaporate water from their leaves, changing the microclimate's moisture content in which they dwell. The water is borne up the tree against gravity's pull by a series of liquid locks in which sugar and salt concentration gradients act to draw water by osmosis. They are able to resist gravity and stand upright partly because of this internal vertical hydraulic pressure. Sense mechanisms in which sodium chloride (salt) is used helps to maintain physical balance as well as sense conditions of moisture content and sunlight. The tree's roots break up the soil to prevent too fast evaporation by capillary action while mining the soil's contents. The trunk and leaves alter and deflect the wind while providing cooling shade.





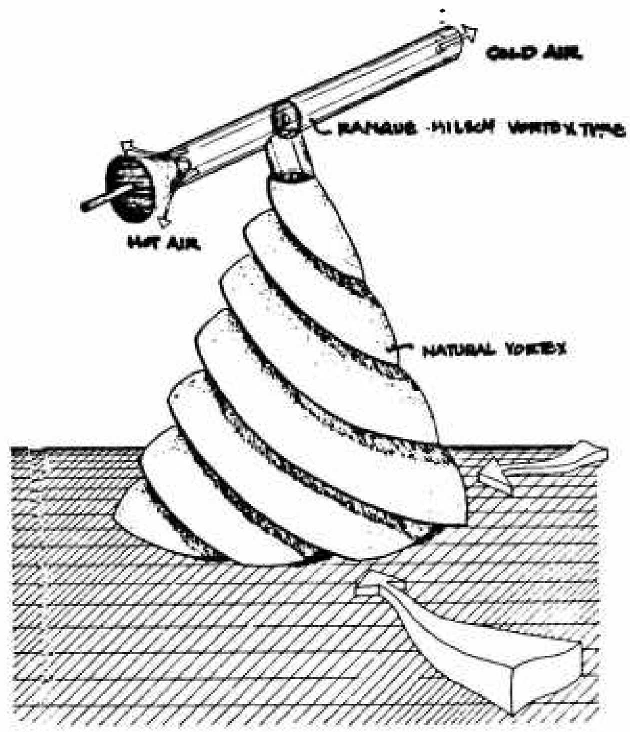
Pumps in the desert

Just as in the tree, it is possible to raise water against gravity, so too a well of water in the desert can pump vertically, against gravity, using the same principle. Evaporation of water from the surface of a funnel shaped well which opens into salty groundwater leaves the contents more brackish. If you insert a one way selective membrane in the bottom of the shaft which allows salt water in (up) but not out, less salty fresher groundwater rushed in to equalize the concentration gradient and thus increase the volume of water in the well, making a vertical pump.

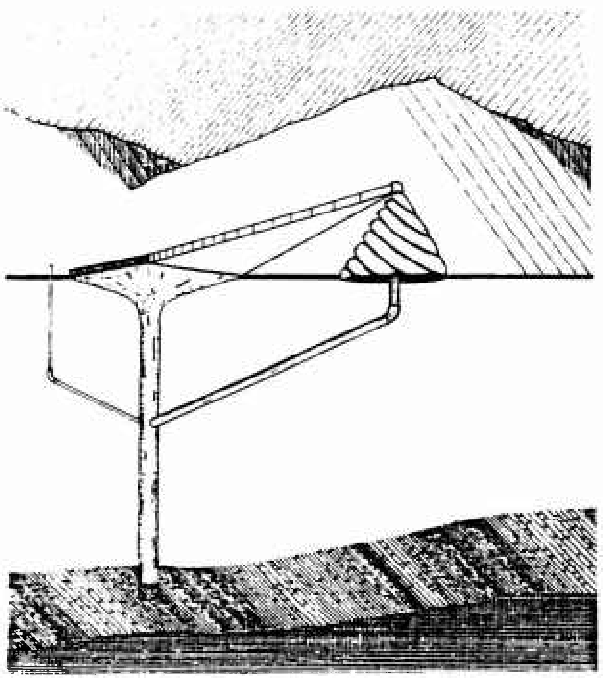


Trees also control the microclimate by modifying wind speed, pressure, direction, thus creating new distributions of energy.

A Ranque-Hilsch vortex tube can be created, a tube which separates hot air of up to 200° from cold air of minus 50° without mechanical parts. Compressed air, which is obtained by a vortex created by design means, is forced into a vortex tube shape with a center escape hole on one side and a valve on the end of the arm on the other side.

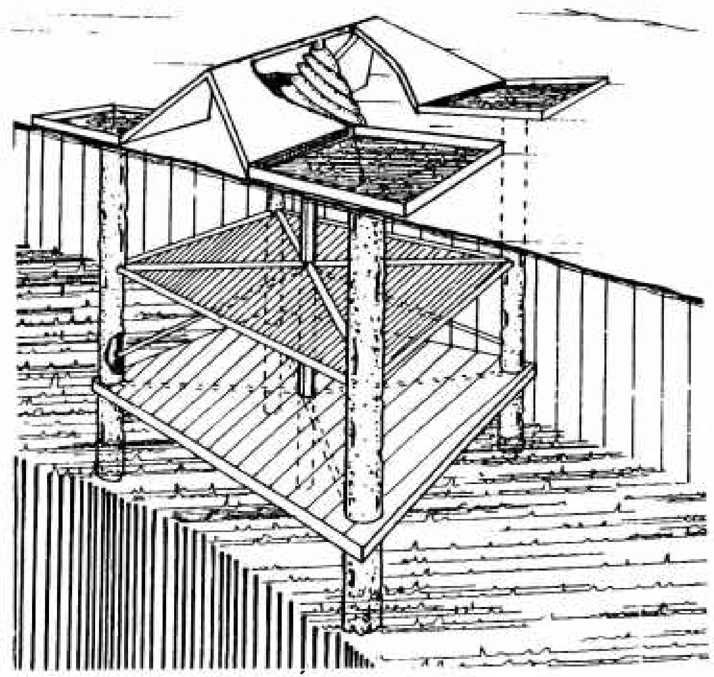


Thinking of this water pump in terms of an oasis habitat, the rising water which originates in the earth is cool or acts to cool the earth's mass through which it rises. The effect is to store cooling capacity in the earth of the desert, thus lowering the temperature and avoiding diurnal temperature shift. But the water tends to become heated as it absorbs the earth's heat. If we add the effects of a Ranque-Hilsch vortex it can
1) be directed to bubble cold air through the water as it heats on its way up through the earth,
2) aid evaporation from the surface by blowing warm air over the water and help draw water up faster.



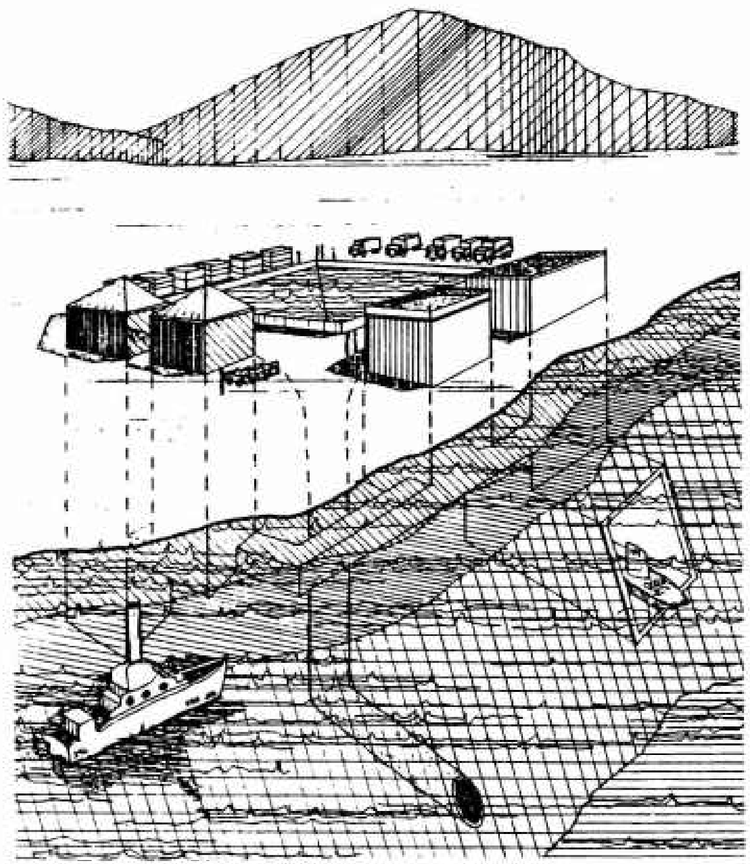
Port Buildings

The tree builds itself partly with nutrients from the soil. The calcium and salts in the brackish water can be deposited as the lining of the well shaft and dish at the surface or bone structure of the building is made from this. The metal armature which holds open the underground well shaft can be hooked to electrodes with a charge and the electrical current produces an electrolytic deposition of minerals onto the armature. There is conceivably the structural system for a desert building system - salt/calcium concrete, and the water pump vortices are the heating/cooling. ventilation system.

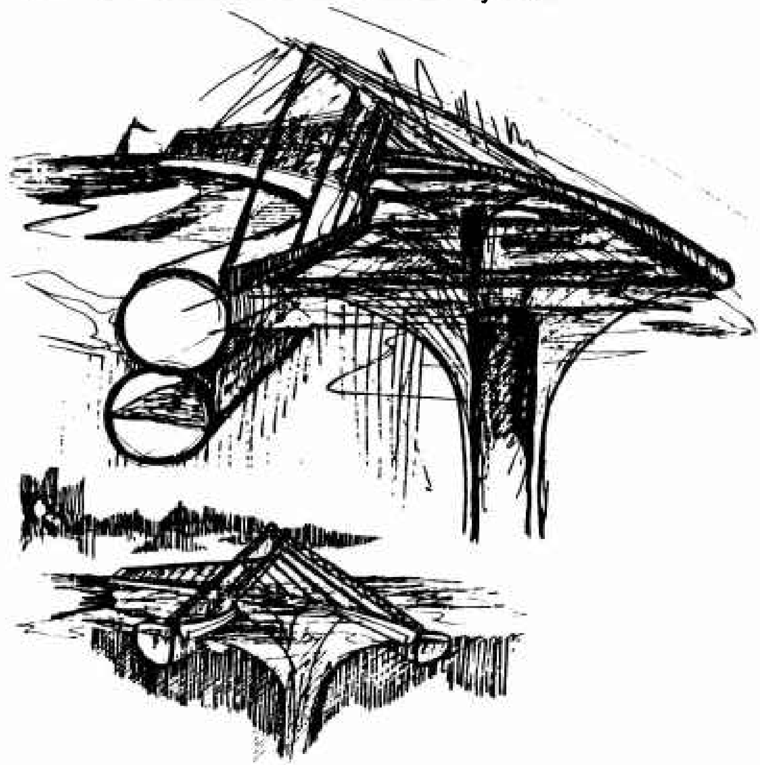


In terms of salinization of the area's water system, this salty water is being channelled up and contained in these structures without seepage and further salinization or rising of the overall water table.

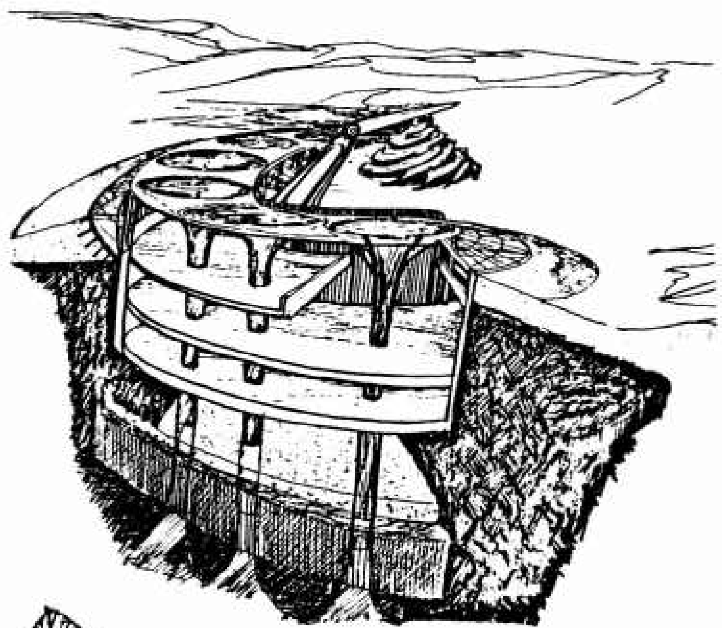
The water vapor given off is fresh water and can be used for irrigation if reclaimed. The top

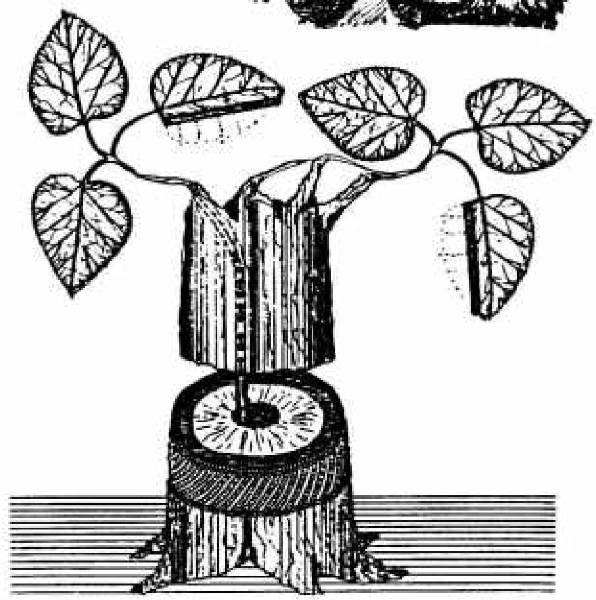


layer of soil of our oasis is a special substrate which acts as a dessicant (non-salty) to capture air borne moisture to hold it. It also is broken up enough to avoid problems of capillary action to the surface, for increased evaporation. Real desert plants and trees are grown here which have low evapotranspiration rates and whose canopy shades and cools the area to contain the vapor long enough to be absorbed. Or perhaps cool air directed from the vortex can make the vapor condense over the soil or as a last resort the vapor-laden air is contained in a closed system.

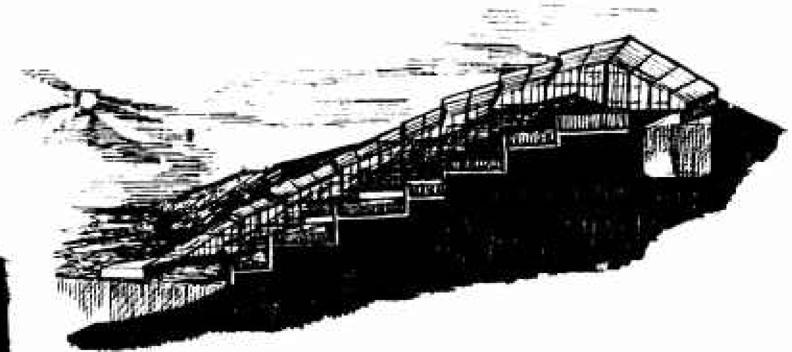


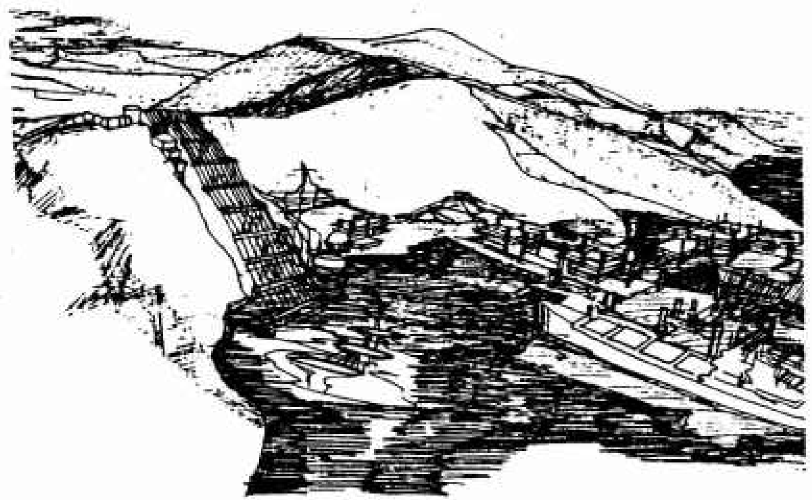
This design has used the tree analogy by: a) pumping water against gravity; b) mining its contents for its own structure against gravity; c) cooling by evaporating water vapor; d) altering wind patterns thus cooling and evaporating; e) controlling water content of the soil; f) preventing too rapid loss of soil water by breaking up the soil; g) also sensing with sodium chloride. It takes advantage of the desert attributes: a) lack of water or uncontrolled excessive evapotranspiration; b) brackish ground water; c) strong winds; d) excessive heat; e) daily temperature shifts. It solves the problems of the desert or desertified areas which are: a) salinization of soils by raising the salty water table due to improper irrigation which then allows salt to leak through by capillary action; b) soil erosion by uncontrolled wind and water action; c) elimination of vegetation; d) inability of soil to retain water; d) loss of habitat for animals and humans. It produces a habitat which: a) gets plenty of water by concentration gradient pumping from ground water; b) by using the ability of the desert to evaporate fast; c) and build with the salt and calcium from the brackish water; d) and so lowers the groundwater table to prevent uncontrolled salinization of the soils; e) cools the earth with this water and cooled air; f) which is produced by the desert winds blowing into a vortex design; g) uses a broken up substrate to prevent water loss by capillary action and to attract back the water evaporated out by the pump's well and restore vegetation with low evapotranspiration; h) which will help control erosion, water retention, and restore the habitat.

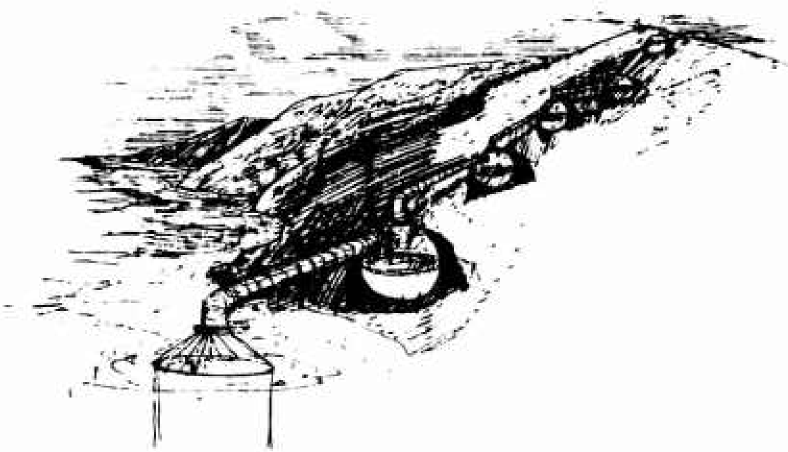




The evaporative pump in a closed system which causes the vapor to condense may be used at an angle as a way to transport fresh water from the sea up and inland to desert regions.







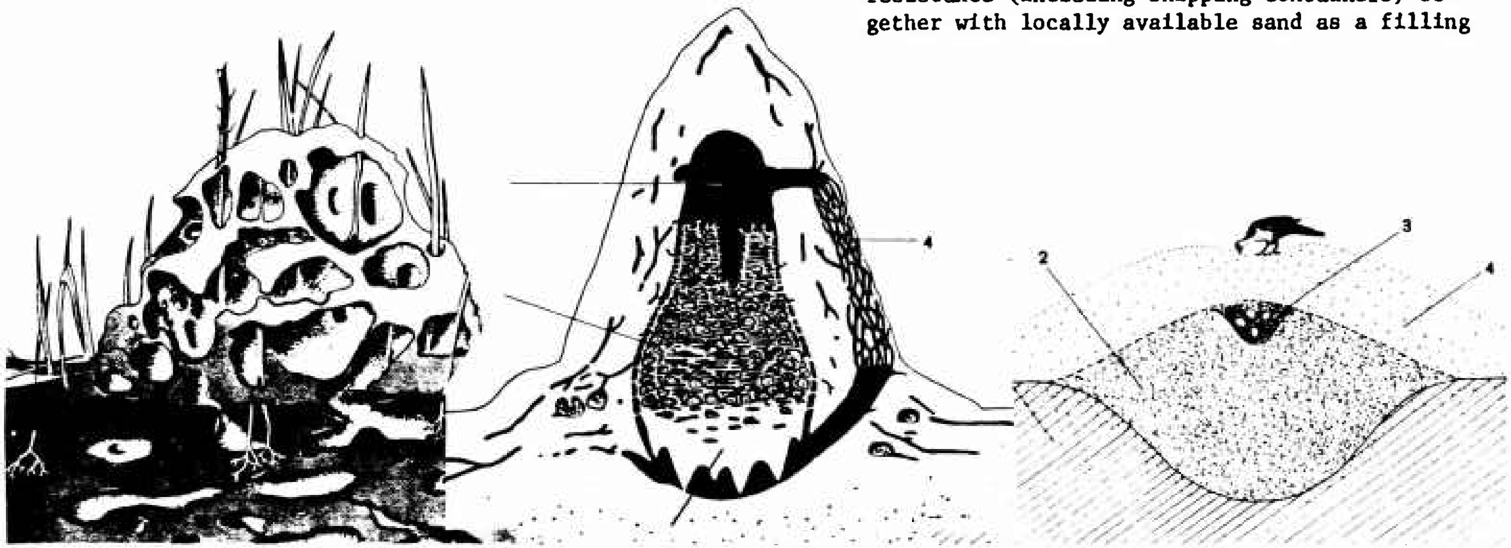
Ports in deserts having sandy soil:

Another idea for ports focuses on coastal tropical deserts having sandy soil. Mobility of the soil material is characteristic of sand. The hydrological conditions of sand dunes are: relatively low level of mineralized groundwater, rapid absorption of atmospheric waters and their gradual downward percolation (gravitation process), water vapor condensation in the upper sandy layer resulting in the under surface wet horizon (5-10 feet).[21] Much of the freshwater accumulating in the groundwater layer results from atmospheric vapor condensation, which then penetrates deeper. The poor capillarity of sandy ground reduces surface evaporation. Methods of reclamation for coastal sand deserts are to make the fresh groundwater horizon accessible for the root system of trees, plants, shrubs.

This project proposes using sand as a building material, not only for its climate modification effects due to mass and the slow evaporation of water but also as a substrate for growing certain types of plants because sand evaporates its water slowly and acts to get moisture out of the air. It will need to be stabilized to avoid blowing away and to have the water retention enhanced. The proposal is to use a substrate to stabilize the sand, retain water and feed nutrients to the vegetative material.

Several ideas suggest themselves -- using sand as a building material in prefabricated earth-covered buildings, using substrates for soil stabilization and/or as a base for growing vegetation.

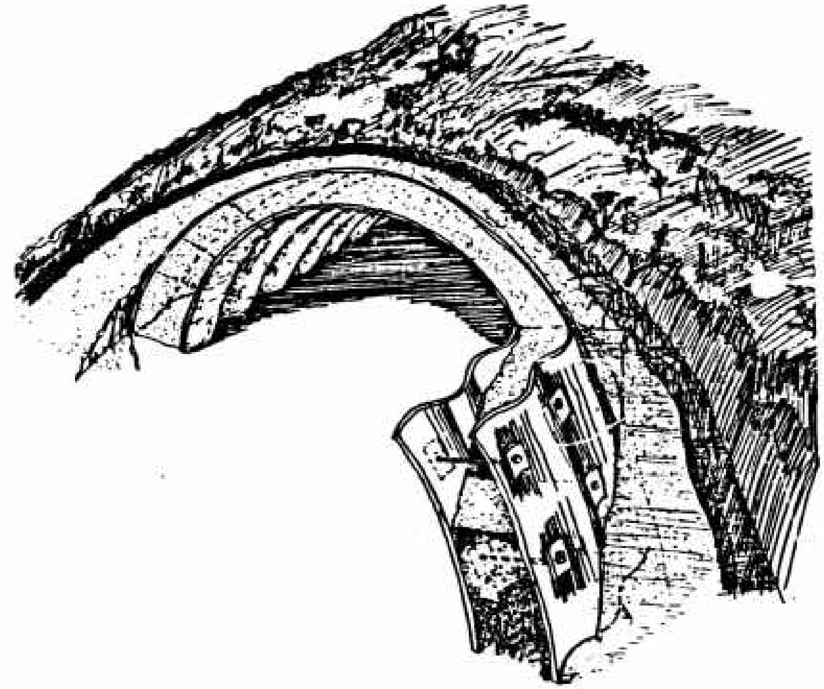
One idea is by the combination of standard prefabricated elements providing form and tension resistance (including shipping containers) together with locally available sand as a filling

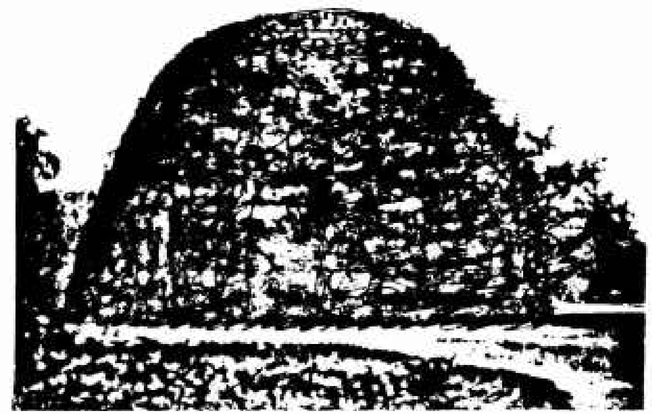


and compression stress, load bearing and thermal mass material, low cost fast constructed and comfortable low energy buildings.

The one basic concept underlying this idea is that by combining the mechanical properties various prefabricated materials and elements used ordinarily as forms, as well as shipping containers, together with locally available sand to provide thermal mass, load bearing capacity for vertical forces and horizontal compression forces, it would be possible to obtain building systems of low cost, fast construction and high thermal quality (especially in desert regions).

The goals are: 1) to integrate prefabricated forms and tension members with natural sand filling and for compression stress and load bearing capacity; 2) to develop the climatic control concepts of utilizing the sand for maintaining indoor comfort while minimizing energy demand for heating and cooling; 3) to develop techniques for utilizing substrates for sand stabilization and moisture holding, to be used as a base for plantggrowth, as well as study of the potential for imparting structural capabilities for sand/plants combinations.



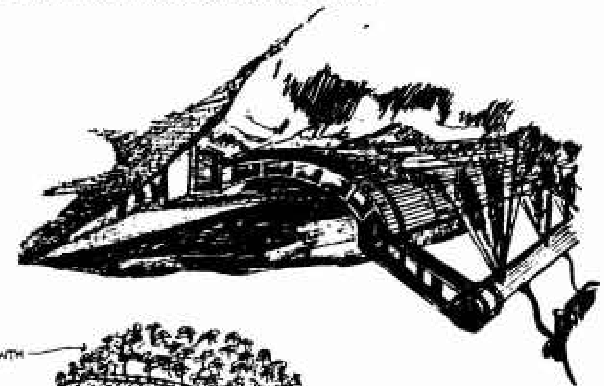


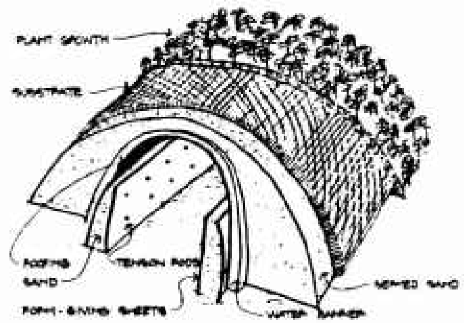
The second idea in sandy soil desert locations is to use sand as a building material by mixing it directly with the substrates so that this mixture can be used both as the building material itself and as the substrate for vegetation growth. This mixture would include sand, a binder, plant nutrient, and a moisture retainer.

A substrate for desert areas described above should have the following properties: 1) when it is wind or rain-eroded the soil or sand sticks in proper configuration; 2) plants can grow here -- they can get nutrients; 3) it can hold moisture and prevent too rapid evaporation -- by having internal air pockets where evaporation is slower; 4) it can attain or collect moisture -- it should be able to hold moisture in the form of liquid and also grab it from the air as water vapor; 5) it provides cooling -- it cools the surroundings by taking away heat or moisture or by absorbing heat itself; 6) it dampens the diurnal temperature swings -- it can take on heat and give it off or remove and add heat to the environment; 7) it can be distributed in space -- so it should be structural.

The substrates we found which are currently available are designed specifically to stabilize sand or soil, from plants and retain moisture: 1)Hydromulch contains water, seaweed products, a small amount of cement, and seeds; 2) an oil by-product very like a thin asphalt with seeds; 3) dried peat moss with a form-giving membrane; 4) improvisation with a mixture of silica gel, agar-agar and sponge combination.[22]

The methods of ordering are: 1) the hydromulch is distributed by spraying onto a formwork to give it shape, or sprayed on a surface and then folded into shape upon which the botanical material emerges: this plant material then responds to the environment (reinforcing formwork method); 2) asphalt can be sprayed on a slip-form to give it order while it hardens (the means of material transformation) -- the dwelling is the hollow area left by the slip-form; 3) peat moss is dried and pre-formed (encoded form), sent to the location, when moisture is added it expands in a few minutes to be a pop-up dome (water absorption gives the energy to distribute into the expanded shape). Plant materials in succession provide an environmentally adaptive dwelling; 4) the mixture of silica gel, agar-agar, and sponge material, cement and seeds is distributed onto a framework and dries out. As the plant material grows, much of the substrate is dissolved and used by the plant for nutrition. This is a version of lost formwork or biodegradable form.





APPENDICES

APPENDIX A LAWS OF NATURAL PROCESSES

I. Phase Changing

1) Phase Diagrams
2) Vapor Pressure
3) Principle of Boiling
4) Raoult's Law
5) Boiling Point Elevation
6) Freezing Point Depression
7) Solid-Liquid Interactions

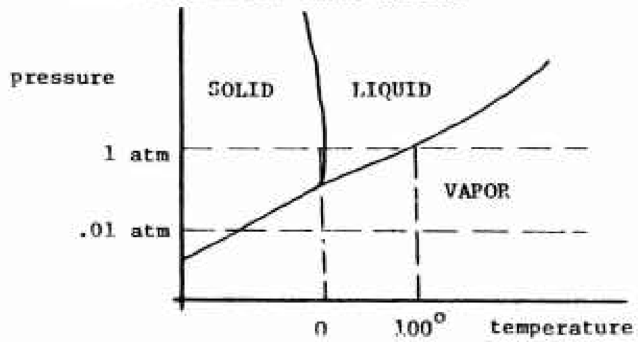
II. Osmotic Pressure

III. Calcareous Generation

1) Henri's Law

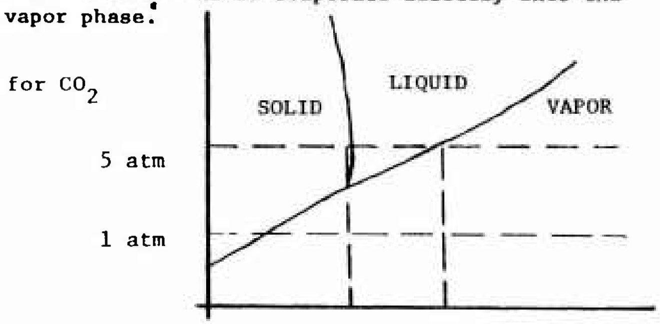
IV. Electrically-Induced Magnetic Field

I. PHASE DIAGRAMS AND PHASE CHANGES



Phase diagrams reveal which "phase" an element or compound is in, given the conditions of pressure and temperature.

For example, at a pressure of 1 atmosphere, the phase changing temperatures are 0° and 100°, for freezing and boiling, respectively. At a reduced pressure of .01 atmosphere, it is possible for the solid ice to evaporate directly into the vapor phase.

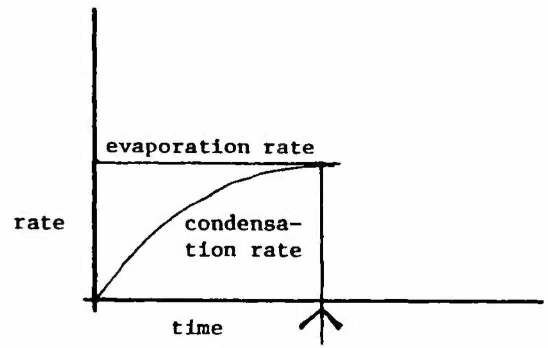


Phase diagrams differ for every compound. CO_2, for example, under the normal pressure of 1 atmosphere, will skip the liquid phase. The pressure would have to be raised near 5 atmospheres in order to acheive carbon dioxide in the liquid phase.

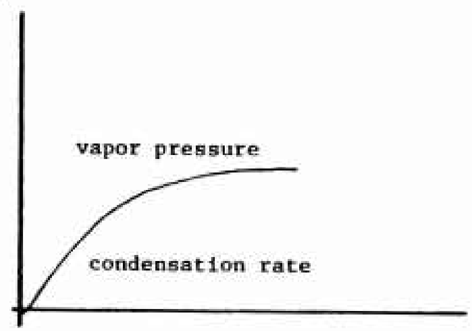
Vapor pressure - determines phase changes.

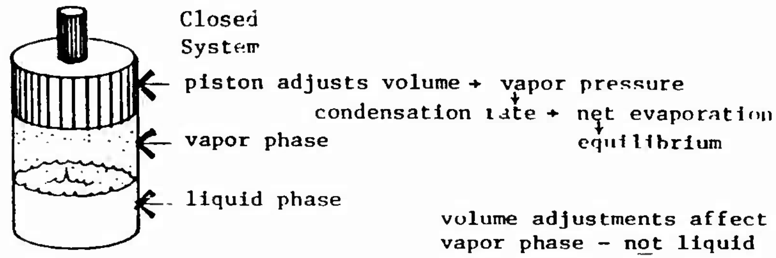
Evaporation - the binding potential energy "holds" molecules to the liquid phase.

When kinetic energy exceeds binding energy, molecules enter vapor phase.



In closed vessel (at constant temperature), evaporation ensues, but as more molecules enter vapor phase, vapor pressure increases and condensation increases proportionately. Finally, equilibrium is reached, and <u>net</u> evaporation is zero.



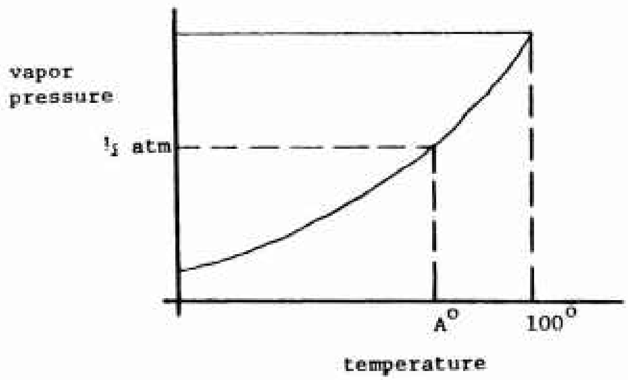


Volume adjustments affect vapor phase - NOT liquid.

When temperature is raised, kinetic energy (vapor pressure) is raised.

When vapor pressure = 1 atmosphere - boiling begins.

Vapor pressure determines the point where a solvent boils.



Additionally, as shown in the diagram, vapor pressure is a function of the temperature.

Boiling occurs when the vapor pressure reaches the pressure of the environment.

Example: when the pressure is at 1 atmosphere, the temperature must be raised to 100°C in order for the vapor pressure to equal this, and for boiling to occur.

Example: if the solvent is at a lower temperature, A^o, where the vapor pressure is ½ atmospheres, the water will not boil, since the vapor pressure (½ atm.) is less than the environment's pressure (1 atm.). But, if the environment is artifically depressurized to ½ atm. by a vacuum pump, then the vapor pressure equals the environmental pressure, and boiling ensues. (This is why water can boil at lower temperatures in the mountains.)

Also, the vapor pressure of a pure liquid is more than the vapor pressure of that liquid containing impurities.

"Raoult's Law" describes this behavior:

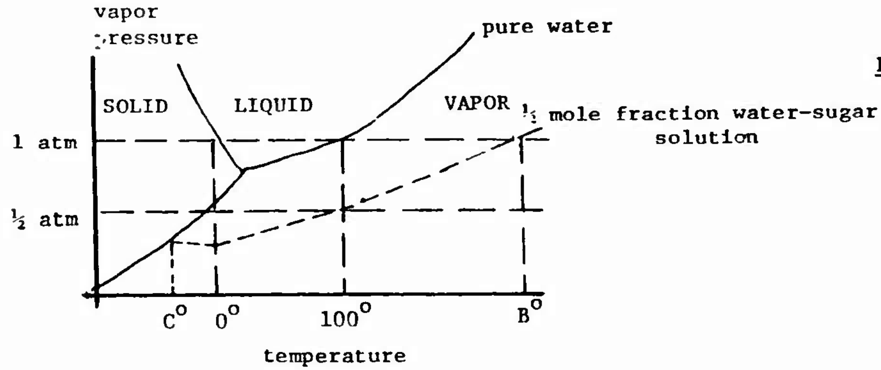
$$P_A = X_A P^o_A$$

P_A	X_A	P^o_A
new vapor pressure of liquid A in solution	percentage (mole fraction) of liquid A in total colution with impurities	vapor pressure of pure liquid A

For example, if the vapor pressure of water at 100°C equals 1 atm., then P^o_A = 1 atm.
If a colution of half water and half sugar is mixed, the mole fraction of water is .5 (X_A = .5).

Conclusion: by Raoult's Law, the new vapor pressure of water in the solution is ½ atm., and now, the water will obviously not boil since the vapor pressure (½) is less than the environment's pressure (1 atm.).

When this principle is applied to the previous phase diagrams, another conclusion can be derived.



Essentially, the lower purity of water will lower its vapor pressure.

1) Pure water will boil at 100°C @ 1 atm. environmental pressure, because the vapor pressure @ 100°C (1 atm.) is greater than or equal to the environmental pressure.

2) However, the vapor pressure of the half and half water solution is only ½ atm., which is lower than the environmental pressure of 1 atm. (Thus, the solution <u>will not</u> boil off at 100°C.) Instead, the temperature must be raised to some point B°, in order for the vapor pressure to equal the environmental pressure of 1 atm. (boiling). This is the principle of "Boiling Point Elevation."

3) Likewise, the Freezing Point is <u>depressed</u> to some temperature C°, in the half and half solution.

<u>Boiling Point Elevation</u> follows the equation:

$$\Delta T = K_b\, m$$

where ΔT = the increase in the boiling point

m = the concentration of the impurities in moles of impurity

K_b = the "molal boiling point elevation constant" which is different for every solvent.

Some sample K_b constants:

	K_b
water	.51
benzene	2.53
acetate	2.93
chloroform	3.63

As shown by these figures, water is <u>least</u> affected by impurities when it comes to boiling point elevation.

Similarly, <u>Freezing Point Depression</u> follows the equation:

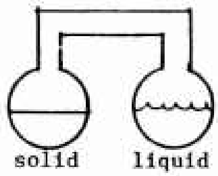
$$\Delta T = K_f\, m$$

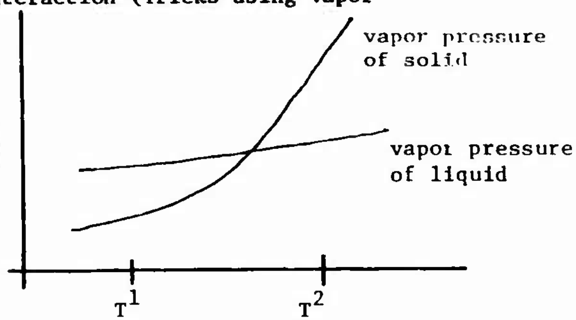
Some samples:

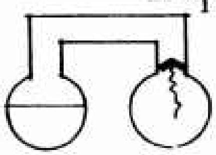
	K_b
water	1.86
acetate	3.90
benzene	5.12
napthalene	6.80

Once again, water is least influenced by impurity concentrations.

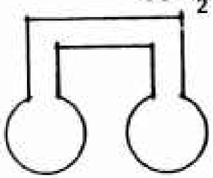
Solid-Liquid Interaction (Tricks using Vapor Pressure)







at T_1: pressure above liquid is higher than above solid. Vapor flow goes to <u>solid</u> bulb.
(Liquid evaporates, vapor condenses into solid side.)



at T_2: pressure of solid is higher. Vapor flows to liquid.
(Solid evaporates, vapor condenses into liquid phase.)

This trick can also be done with two solids: using salt as an impurity to regulate vapor pressures.

Here, the vapor pressure of ice block-B is lowered; ... since environmental pressure is zero, the higher vapor pressure of A will make ice-A evaporate. Ice block B with the lower vapor pressure will attract the vapor and condense it.

II. OSMOTIC PRESSURE

Osmotic pressure = π = cRT

where "c" = concentration <u>difference</u> <u>between two chambers</u>

"R" = gas constant

$$= 0.082 \frac{\text{liter-atm}}{\text{mole-deg}}$$

"t" = standard temperature (^{o}Kelvin)

Combining osmotic effects with:

1) Properties of ice formation
   (ICE BUILDING UPWARD)
2) Properties of vapor pressure
   (COOLING MECHANISM, WATER MOVEMENT)
3) Evaporation
   (WATER MOVEMENT TOWARDS INLAND DESERT)

III. CALCAREOUS GENERATION (Chemistry)

CO_2 (gas) CO_2(dissolved)

regulated by Henri's Law

H_2O

H_2CO_3 = carbonic acid

4.3×10^7

H^+ HCO_3 = bicarbonate ion

H^+ CO_3 = carbonate ion

Ca^{++} Mg^{++}

$CaCO_3$ $MgCO_3$

<u>Henri's Law</u>

$$P = k_H \times X$$

P = vapor pressure above

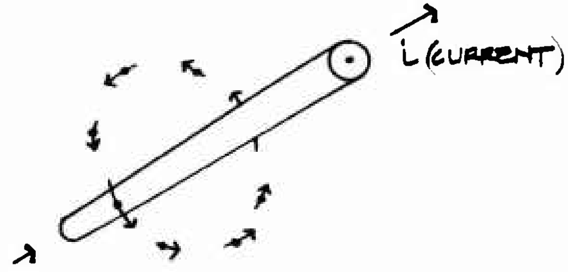
k_H = Henri constant

X = mole fraction dissolved in liquid

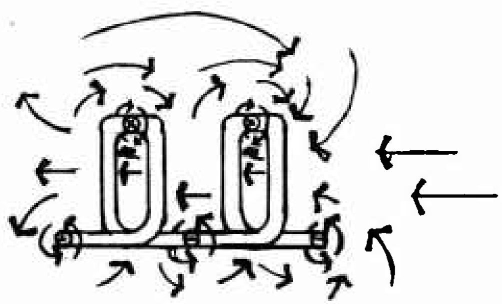
Henri's Law says that the amount of gas which is dissolved in a liquid is dependent on the pressure of that <u>gas</u> found above the liquid.

IV. ELECTRICALLY-INDUCED MAGNETIC FIELDS

"Pivoting" magnetic dipoles (compasses) reveal a magnetic field following the "right-hand rule."



Now, rearrange the current through a <u>coiled</u> wire:



APPENDIX B

I. CRITERIA FOR PORT DESIGN

The Servicing Functional Aspects

State of the art and needs

"Recent developments in marine shipping will have a profound effect on military port construction. The use of large container vessels and super tankers already requires that commercial marine terminals be extensively modified in order to operate efficiently. The Navy must develop the capability to construct facilities that are compatible with these new developments.

It is actually somewhat ironic that the military introduced the wide-scale use of roll-on/roll-off techniques, the use of large freight containers, and the use of lighter aboard ships (LASH). Civilian developments emanating from these concepts have outdistanced existing military capability for rapid employment of container ships.

Containerization:

Containerization of cargo, as we know it today, has a number of advantages for military logistics operations. It allows ships to be off-loaded seven to ten times faster than ships carrying break-bulk cargo, thus reducing the required number of berthing facilities. Containerization also allows the cargo to clear the port in a minimum time with a high degree of economy and eliminates the need for large quantities of covered storage. It also reduces pilferage and the need for large security forces.

On the other hand, there are a number of disadvantages to containerization. Because a large container ship will repl ce five break-bulk vessels, the loss of one ship will have five times the impact on the total system. One container berth is equal to seven to ten break-bulk berths, and its loss can have a staggering effect if reserve facilities are not available. Each berth must be supplemented by large transient storage areas to achieve potential discharge rates, and many existing ports have only limited space available. Large capital investments and tremendous demands for good management are necessary for the containerization system to operate efficiently.

Large high-speed container ships:

Container ships have increased steadily in size since the first ships were created by modifying existing break-bulk vessels. As the traffic in containerized cargo has increased and terminals capable of handling large volumes of containers have been constructed, the large container ships have become more economically attractive. Vessels are now in operation and under construction that will carry more than two thousand 20-ft container equivalents. A number of ships are more than 900 ft long and 100 ft wide, and draw more than 35 ft of water when fully loaded. Displacements run in excess of 40,000 long tons.

From a construction standpoint, the possible introduction of ships of this size into a military operation is of great importance. Berth facilities must be 1000 ft long or longer, and channel depths must be maintained in excess of 40 ft. Container cranes must be capable of lifting containers up to 110 ft from the face of the fender. Fendering piers and wharves in exposed locations will involve a major design and construction effort. Transient storage areas will have to be large and carefully designed to permit the unimpeded flow of container handling equipment.

Roll-on/roll off ships:

The major advantage of roll-on/roll-off ships over lift-on/lift-off ships is their fast turnaround time in port. This advantage may offset the large loss of shipping cubage on relatively short hauls when the time spent in port is a significant portion of the total cycle. Roll-on/roll-off ships also permit a reduction in the number of terminal facilities because more ships can use an individual facility, and the cargo can be cleared from the port very rapidly. In addition to these vessels, there is an increasing number of ships such as those operated by the Atlantic Container Line which combine container life-on/lift-off systems with roll-on/roll-off systems. These vessels offer the advantages of either system, depending on the needs of a particular customer. Construction considerations for roll-on/roll-off ships vary considerably depending on the size of the ships using the facility, the locations of their doors and ramps, and the tidal range of the port. Navy LST's have their ramps through or over the bow, while most commercial vessels have either stern ramps, side doors, or both. There appears to be no specific facility design that is compatible with all types of ships.

Container handling equipment:

At the present, standard commercial containers may weigh up to 30 long tons (67,200 lb). Equipment capable of lifting and moving loads of this magnitude is commercially available. Little work has been done, however, on the effect that container handling equipment has on flexible and rigid pavements, and virtually no work has been done on the effect of container handling equipment on expedient surfaces and unsurfaced soils. The problem of designing pavements and marine structures to carry these loads is great.

Shipboard and pier-mounted cranes:

Most existing deck cranes were not capable of lifting large freight containers when they were first introduced. Therefore, the early container ships were made self-sustaining by equipping them with their own deck-mounted gantry cranes. As the container trade routes developed and new container shipping facilities were constructed, the new facilities were equipped with pier-mounted gantry cranes designed for container operations.

With these pier-mounted cranes, it was possible to service a number of ships rather than just the one on which the deck crane was mounted. Pier-mounted cranes are also advantageous in that they do not burden the ship with nonrevenue producing cargo. Also, pier-mounted cranes can be ganged at one berth so as many as four cranes can service a ship when the other berths along the wharf are not occupied.

From a construction standpoint, these new cranes presented some interesting design problems. For one, the larger cranes weigh 500 tons or more, with design wheel loads of 100,000 lb on 4- to 5-ft centers. Piers had to be built that were capable of supporting these cranes as well as uniform live deck loads of 1000 lb/sq ft. The Army's DeLong barge was designed for break-bulk cargo of 600 lb/sq ft. Another problem involved with pier-mounted gantry cranes is that they take from two to five months to erect and prepare for operation. This is hardly compatible with the time constraints of most military logistics operations.

Heavy-lift helicopters:

A number of studies and tests have been made to determine the helicopter's ability to discharge container ships at sea. For the most part, these studies have shown that the costs are excessive and that some means must be available for removing hatch covers and preventing containers stored below deck from jamming in their cell guides during pick-up. The heavy-lift helicopter also requires major construction effort ashore in the form of dust palliation and surfacing mediums.

Barge ships:

One of the latest developments in marine shipping has been the use of barges as containers. There are presently two different systems in use; the LASH and the Seabee. The LASH ships carry a mixed cargo of 415-short-ton-capacity barges and standard containers. A 500-ton-capacity gantry crane lifts and lowers the barges into vertical cells and transports them to and from the stern. The Seabee barge ship carries thirty-eight 850-ton-capacity barges that are lifted from the water by a 2000-ton-capacity marine elevator. The barges are stored on three noncellular decks and are moved by a transporter mounted on rollers.

Both of these ships will have a significant influence on construction because they are self-sustaining and they can transport extremely large prefabricated engineer modules. The Seabee is able to transport barges up to 100 ft long and 70 ft wide on its top deck. If shortened, the DeLong "B" barge can be shipped to overseas locations three and one-half times faster than by the present method of towing. The ship can also transport construction barges, dredges, tugs, landing craft, petroleum tanks, floating cranes, standard containers, helicopters, and wheeled and tracked vehicles. Because of its non-cellular horizontal hold, the Seabee can also be easily transformed into a tanker, troop carrier, or hospital ship by inserting tanks or compartmented modules.

The standard LASH and Seabee barges are ideal for military operations because their shallow drafts and narrow beams allow them to be towed into restricted waters and unloaded by cranes currently in the inventory. This greatly reduces the dependency on dredging, wreckage clearance, and the construction of piers, wharves, tank farms, power generating facilities, machine shops, and repair parts facilities in the early stages of port development.

Large tankers:

In 1955, 92.8 percent of the world tanker fleet tonnage was hauled in ships of 30,000 dwt capacity or less, and ships over 50,000 dwt capacity were just being introduced. By 1970, only 21.9 percent of the total tonnage was hauled in ships of 30,000 dwt capacity or less, and 52.5 percent was hauled in tankers of over 50,000 dwt capacity. These facts are important because tankers over 50,000 dwt capacity normally draw 50 ft of water or more when fully loaded.

The use of large tankers will require construction of facilities with adequate water depths, high-capacity discharge systems, large tank farms, and effective provisions for controlling spillage. These facilities must be capable of being constructed under much more severe time restraints than is normally required for the construction of civilian facilities."

It is informative to look at the last World War, too.

"The Chief Engineer from that period concluded that experience in the ETO showed that it is impossible to place too much emphasis on the value of modern, large-capacity construction equipment. He praised the 40-ton crawler crane as the most valuable individual piece of equipment but noted that there was a shortage of 60-ton trailers on which to transport them. Adequate dredging equipment was not available in sufficient quantities. Of the four hopper dredges available, only the shallow-draft "Hoffman" could be gainfully employed. A dipper or bucket dredge with a capacity of approximately 8 cu yd would have been of great assistance in removing underwater debris alongside the quays had one been available. Port repair ships were primarily used for their machine shops. When such ships are used, they should be amply supplied with various sizes of stock and plate.

Although no specific deficiencies were noted in the area of port construction, descriptions of individual operations indicated that seldom were pile-supported wharves constructed in less than 60 days after an operation began; usually construction of such wharves took much longer. Floating piers constructed of Navy pontoons were usually assembled in a matter of days from causeway sections and 5 by 12 barges. These units apparently performed adequately when located in protected areas.

If there is insufficient time for dredging, the ammunition facility must be located in the outer harbor, or there must be a reliance in lighterage. LASH and Seabee systems will apparently make problems worse by flooding the port with a large number of loaded barges. If these barges are spread out according to safety regulations, the entire inner harbor is contaminated for other uses.

If dredging is possible, the ammunition facility may be moved into the inner harbor, but must be located well north of the airstrip. The tanker discharge facility should then be moved to a safer location in the outer harbor. Alternate pipelines should be run to the dry cargo or ammunition piers and charged with water for fire fighting. These same lines should be capable of handling POL in the event that something happens to the main POL facility. Of course, this same philosophy can be applied to the ammunition facility. If possible, at least one break-bulk facility should be separated from the rest to act as a backup to the primary ammunition pier or wharf.

Port construction in the Theater of Operations (TO) must be responsive to both the current and immediate needs, strategic and tactical, of Navy forces. It must consider the receipt, storage, and dissemination of enormous volumes of supplies that are required in support of the military operations. In addition, the construction must be responsive to the requirements of supporting elements of the Army and Air Force. Since the port and component facilities represent construction effort of major proportions and since time is a vital factor, comprehensive and visionary planning is of an essence. The planning must consider the mission of the port, its requirements, general geographic location, tentative methods of construction, and personnel, and material requirements.

Prefabricated reinforced concrete pier module:

As a result of recent developments in shipping, a need has arisen for a prefabricated pier component capable of handling live loads of 1000 lb/sq ft, high concentrated wheel loads, and a gantry-type container crane.

A preliminary study was conducted by the Army to determine the feasibility of designing a reinforced concrete pier component that would (a) fit on the Seabee barge ship, (b) weigh less than 1000 tons, (c) have a deck live load capacity of 1000 lb/sq ft and large concentrated wheel loads, and (d) support a gantry-type container crane (wheel loads of 1000 kips on 5-ft centers).

The concept would be that this module could be loaded on the Seabee barge ship to be transported to the TO. Twenty-nine barges would permit the construction of a 1000-ft-long pier or wharf. The modules were designed for use with 6-ft-diameter caissons and the 500-ton-capacity DeLong jacks. The modules would be unloaded from the barge ship and floated into place. Through use of four caissons and DeLong jacks, the modules would be jacked to their required elevation, and then 24-in-diam piles would be driven through precast holes and epoxied to the girders. After the 24-in-diam piles were in place, the four caissons and DeLong jacks would be withdrawn to be used on another module.

The module would be filled with a fine-grained material like sand with pavement placed over it, thus resulting in a relieving-type structure. This type of construction is used in commercial ports to allow high concentrated wheel loads and heavy loads to be dispersed over a number of pilings. The module could also be used as a causeway with a roadway width of 35 ft.

Roll-on/roll off facilities:

The United States Army is the world's largest user of roll-on/roll-off vessels, mostly in the form of landing craft. In early stages of an amphibious operation, landing craft, lighters, and Navy landing ships can be expected to provide a major portion of the resupply tonnage. Landing beaches will be in continuous use. After a port site has been secured, lighter operations employing landing craft and barges may still continue. These vessels may be employed to handle ammunition, carrying it from the roadstead to the inner harbor where mooring fully loaded ammunition ships would be too great a safety hazard. Experience in Vietnam with the maintenance of landing craft beaches indicated some lack of understanding of the equipment utilizing the facilities. The result was the construction of structures that were not as functional as they could have been and that often required more maintenance effort than the austere facilities they replaced.

Roll-on/roll-off ramps:

No general solution was found to the problem of providing facilities for discharging commercial roll-on/roll-off ships. There appears to be no standard height above water level of either side doors or stern ramps. Because the difference between loaded and light draft of a ship may be as much as 20 ft and the tidal variation within many harbors is 10 ft or more, provisions may be necessary to accommodate a change in elevation of stern and side doors of as much as 30 ft. If the gradient on a ramp is limited to 30 percent to ensure rapid discharge and loading of vehicles, a total ramp length of 60 to 70 ft may be required, depending on the elevation at the shore end.

Commercial roll-on/roll-off vessels:

At military harbors where DeLong barges are used for container facilities, the top deck may be 20 ft or more above water level, even at high tide. This makes is extremely difficult to

construct pile-supported ramps that will match up with both the ship's ramp and the pier deck.

Landing craft facilities:

There are several very important factors that should be taken into consideration in the design of landing craft beaches or "ramps." One of the most important aspects is to fully understand the environmental conditions for which a landing craft was designed and the normal beaching and extraction procedures.

Landing craft presently in the inventory were designed for use on beaches with gradients greater than 6 percent. With normal beaching loads, these craft draw 3 to 4 ft of water at the bow. If a landing craft is not to dry out with an outgoing tide, the shore landing ramp must extend out from the shoreline to within 20 ft of where 3 ft of water exists at low tide, assuming that the beach gradient is sufficient to preclude grounding at the stern of the vessel.

If it is assumed that the point of grounding at the bow is 20 ft from the end of the lowered bow ramp, the gradient of the face of the beach ramp must be about 3:20, or about 15 percent. The ramp must be constructed out of material with the following characteristics:

a. It must be able to withstand the trafficking of heavy-material-handling equipment while in a completely saturated condition.

b. It must provide adequate traction to vehicles entering or exiting the craft.

c. It must be flexible enough to prevent serious damage to the landing craft using the facility.

d. It must be able to resist the scour action caused by the prop wash of landing craft exiting the facility and from currents flowing parallel with the shoreline.

The most practical materials that will satisfy these necessary qualities are crushed rock, gravel, or small cobbles.

Tanker discharge facilities:

The increasing need for petroleum in the TO makes it essential to develop tanker discharge facilities as soon as possible. During the investigation of these facilities, some equipment and methods were studied that may allow rapid construction of petroleum facilities.

In the initial stages of port development, either tankers or barges can be employed as POL storage facilities. A 122,000-bbl-capacity barge constructed from a T-2 tanker hull has four cargo pumps which can discharge 17,140 bbl per hour against a 300 ft head. Smaller liquid cargo barges could be transported overseas aboard barge ships and either moored within a port or moved ashore on a compressed air cushion.

The primary disadvantage of floating storage is its vulnerability and the threat that a major spill would have on the rest of the port. Oil booms and recovery equipment as well as fire fighting equipment must be on hand.

The discharge of tankers directly ashore has been a problem that has received a great deal of attention for a number of years. Several developments have been made toward solving this problem such as the retrievable hoseline, collapsible tanks, single-point mooring buoys, and explosive anchors.

By the time a port is secured, however, more reliable systems will be required to transfer large quantities of petroleum ashore. The most practical

means of laying a pipeline very rapidly appears to be the reel-type pipe laying barge. The Flour RB-2 is capable of carrying 18,000 ft of 12-in-diam American Petroleum Institute pipe and laying it at a rate of 2 miles per hour. With this piece of equipment, a normal submarine pipeline could be laid in one work day.

Presently, the only proven method of mooring a tanker at an exposed site that is compatible with Army requirements is a single-point mooring buoy. This mooring method consists of a buoy normally 25 to 40 ft in diameter, a set of four to eight anchors and chains to hold the buoy in place, and hoselines to connect the buoy to both the tanker and submarine pipeline. The Army currently owns three International Marine and Oil Development Corporation single-point moorings of this type.

DeLong Barge:

The self-elevating spud barge pier, commonly known as the DeLong pier, consists of barge units and a number of spuds or caissons that support the barge above the water.

The design of the barge allows it to be towed from a preparation site to its point of erection. Once at its erection site, the caissons are laced, and the jacking operation can be started. The air jacks are approximately 10¼ ft in height and 10 ft in diameter. Each is capable of raising 500 tons at a nominal rate of 12 ft per hour with individual strokes of 12 in. The barge is supported from each jack by four tie bars. A master control panel synchronizes the operation of the air jacks on all caissons. The jacks can be operated individually through the use of control panels mounted on the side of each.

There are presently two sizes of barges being used in the military system. The "A" barge is 300 ft long, 80 ft wide, and 13 ft deep. It is supported by ten 6-ft-diam caissons and ten 500-ton-capacity jacks. The "B" barge is 150 ft long, 60 ft wide, and 10 ft deep. It is supported by six 6-ft-diam caissons and six 500-ton-capacity jacks. Two "A" barges were used to form a 600-ft-long pier at Da Nang, South Vietnam. A combination of "A" barges to form the pier and "B" barges to form the causeway was used as a temporary facility at Vung Ro Bay, South Vietnam.

The DeLong barge is a welded steel honeycomb-like structure consisting of plates and stiffeners. It is designed to support a uniform live load of 600 lb and a medium-sized tank. The barge is divided into watertight compartments to maintain safe subdivision in case of accident during towing.

DeLong barges as container facilities:

One approach to providing container facilities at military ports would be to utilize existing "A" and "B" DeLong barges in the Army's inventory to support container gantry cranes. Gantry cranes of this type weigh approximately 1,000,000 lb and have design wheel loads of 100,000 lb with wheels on 5-ft centers. Container gantry cranes can average about 20 container lifts per hour and represent the most efficient means of off-loading container ships.

The erection time for a gantry crane is from two to five months, depending on the availability of the parts, construction equipment, and skilled technicians to erect it. At least one (preferably two) 100- to 150-ton-capacity mobile crane is required for erection.

The initial cost of the gantry-type container crane varies according to its specifications, but normally it is approximately $1,000,000. The lead time for manufacturing these cranes is about a year. In a military operation, a crane of this size would present enormous security problems, and repair would be extremely difficult. Also, there is some question as to whether existing DeLong "A" barges can be economically modified to support these cranes.

Another approach to off-loading container ships is through the use of large mobile truck- and crawler-mounted cranes operating from the deck of a DeLong barge. The large mobile cranes are not capable of lifting 40-ft containers weighing 67,200 lb beyond a 90-ft radius. This means that the heavy containers must be loaded into the inboard cells of ships with large beams. However, it will require that personnel responsible for the placement of continaers on the ship know the

unloading capabilities at the ship's destination so that the containers will be placed in cells that are within the lifting capabilities of the cranes at the destination. Ideally, a large mobile crane will average about 15 container lifts per hour. The cost of these large mobile cranes is about one-half the cost of the container gantry cranes. They also have the advantage of being able to perform a number of other heavy-lift operations.

A third approach to container discharge is the use of a series of fixed mounted stiffleg or whirley cranes. Mounting the cranes on platforms would permit the unloading of ships from either side of the pier and provide a clear area beneath the crane for the movement of cargo. The stiffleg system has a low initial cost, is easy to store and maintain, and is quickly erected. The platform could be added to the DeLong barges before towing to the TO and the crane assembled after the barges have been jacked into place. The cyclic times would be very close to those of a large mobile or crawler crane. The stiffleg crane also could be mounted on a barge and used for construction purposes.

Shore connections:

The Ammi pontoon, like the DeLong barge, is a spud-type barge that can be hoisted above the water. The Ammi, however, is designed primarily to supplement and replace the P or I series pontoon causeway sections for the discharge of LST's and landing craft. The Ammi is designed for water depths of approximately 20 ft rather than the 40 to 50 ft of water in which a DeLong barge might be installed. It was concluded that standard Ammi causeway pontoons do not have sufficient structural strength to be employed as a causeway for the DeLong barges.

There appears to be a definite need for a self-elevating pontoon that is between the DeLong "B" barge and the standard Ammi pontoon in both size and strength. This barge should be compatible with either the LASH or Seabee system to permit it to be easily transported to an overseas TO. Its weight should not exceed the lift capability of Army floating cranes (100 short tons). It should be capable of functioning either as a flat-deck cargo barge or as a construction barge. The barge should be capable of performing as an elevated causeway module in water depths of 50 ft. Piling would, therefore, have unbraced lengths of approximately 75 ft. Each barge should be able to support the largest equipment that could be operated on the DeLong barge while in its elevated position. It should provide a roadway width of at least 22 ft (preferably 35 ft). It is desirable that it be equipped to handle liquid cargo after minor modifications, and its hull should be suitable for ocean touring at moderate speeds.

Fenders:

The purpose of a fender system is to protect both the vessel and the docking facility from damage resulting from relative motions between the two. The berthing forces are usually the most critical because loading is concentrated over a fairly small portion of the facility.

Based on the results of a study conducted in 1965 by the Naval Civil Engineering Laboratory,* it was concluded that timber piles with rubber bearing blocks at deck level were the best method (at that time) for fendering Navy piers and wharves at exposed sites.

Surfacing materials:

Many of the newer container ship terminals in the United States are being provided with from 12 to 18 acres of container storage and marshalling area per berth. If this were done in the TO, a port with only one container ship berth would require as much paved area as a medium-lift airfield in the support area. Wheel loads and tire pressures of container handling equipment used at the commercial ports have been determined to be as severe as those of a C-130 aircraft. Therefore, it is clear that it is absolutely essential that military planners be able to determine the amount of surfacing that is required so that sufficient resources can be programmed into a base development plan.

The task of determining surfacing requirements actually involves three decisions: the type of surfacing, the thickness required, and the amount required. All three of these elements are influenced by the characteristics of equipment operating on the surfacing.

a. Determine the ability of sample container handling equipment to operate on unsurfaced soils.

b. Determine the surface area requirements for various types of container handling equipment.

Vehicles with the same load-carrying capabilities may require extremely different surfacing, depending on individual vehicle characteristics. Surfacing requirements vary in type, thickness, and strength in accordance with wheel loads, the number of wheels and their arrangement, and tire contact pressure and contact area. Because of this variation in pavement requirements, the engineering construction and maintenance effort may be several times greater for one vehicle than for another with equal load-carrying capacity.

Traffic volume is a primary consideration in the selection of the type of surfacing and its required thickness. It is essential that an adequate study be made to determine the number of passes and the operational flow patterns of each vehicle under consideration so that a reasonable design volume for a particular facility and vehicle can be selected.

Container selectivity involves the relative ease with which individual containers can be located and removed from a storage area. If containers are not stacked or are mounted on a chassis, selectivity would normally be considered 100 percent because no other containers would have to be moved in order to locate and remove a specific container from storage.

Utilization of space is not particularly efficient, however, if containers are stacked two or three high or in blocks with very little space between containers. Space is maximized at the expense of selectivity. Both locating a container and removing it from the stack would be difficult. The need for selectivity varies considerably. Empty containers need virtually no degree of selectivity, but containers with cargo suitable for throughput need a high degree of selectivity.

Another important factor affecting the effort involved in constructing adequate surfacing at military ports is the amount of area to be surfaced. It is extremely important that the total surface area be limited in order to minimize construction and maintenance efforts. Area requirements vary with vehicle characteristics, operational patterns, container sizes and weights, driver skill, number

of vehicles, and protective measures taken.

Trends at commercial ports in the United States indicate that up to 18 acres of storage and marshalling area may be required for each container ship berth with a maximum retention time of two to three days. With a discharge rate of sixteen 20-ft containers per hour, a storage capacity of 320 containers would represent a once-day, one-direction retention time. Because an equal number of containers must be placed back on the ship, this quantity will double to 640 containers per container ship berth per day. If these containers were temporarily stacked on a 40-ft trailer chassis, approximately 8 acres of surfacing would be required. In a chassis operation of this type, the spacing between trailers in rows and the width of aisles depend on the skill of truck drivers and the characteristics of the vehicles. This variation can result in as much as a 20 percent reduction in the number of containers that can be stored per acre. If straddle carriers are employed, the 640 containers can be stacked two high in an area of only 3 acres.

At many facilities, two and sometimes three gantry cranes are teamed to discharge one ship. Under these circumstances, the storage area requirements and the amount of container handling equipment needed are basically proportional to the number of cranes. If two cranes are employed, a two-directional chassis operation will require approximately 16 acres, and a two-direction operation involving the use of straddle carriers would require approximately 6 acres. As a matter of interest, 16 acres is approximately equal in surface to 6 miles of a 23-ft-wide road.

Presently, approximately 52 percent of the slots in U.S. flag container ships are owned by three companies having containers in primary lengths of 24, 27, and 35 ft. A facility handling more than one size container, other than sizes in even multiples such as 20 and 40 ft, will be less efficient with respect to area requirements than will a facility handling only one size. For example, only one 24-ft container will fit on a 40-ft chassis. Stacking different size containers is not possible because corner posts of the container on top must be aligned with the corner posts of the one below it. Also, locating the proper size container for backloading a ship would be inefficient and time-consuming. The storage area and operational flow patterns would have to be organized to provide separate facilities for each container size. The result would be an increase in area requirements because of a less efficient utilization of space and longer retention times for containers waiting for a ship with the proper size container cells.

Dispersion and/or camouflage may, in some instances, be a factor in area requirements. Although camouflage is somewhat limited in effectiveness as a passive defensive measure for military ports, dispersion of materials awaiting shipment out of the port area is an important consideration. The number of required container handling vehicles is drastically increased in a vastly dispersed operation; also, the required amount of surface area is drastically increased.

Construction cranes:

If it is determined by the Combat Development Command that a large crane will be operating on a barge, consideration should be given to the use of a stiffleg derrick or crane. Stiffleg derricks and cranes cost about half as much as mobile cranes of similar capacity. The stiffleg derrick sacrifices the capability of full rotation and mobility for the advantage of using the barge as

as a counterweight. Stiffleg cranes are relatively easy to erect, and the hoist and other components can be replaced if they are damaged.

Pile driving equipment:

The driving of the DeLong caissons requires a large offshore pile hammer with a ram weight of approximately 40,000 lb and a stroke of 3 ft. Hammers of this size weigh approximately 50 to 55 tons. The hanging head sections and hook blo block required to support the hammer may weigh up to 20 tons. Cranes capable of handling loads of this magnitude have commercial ratings of 150 to 200 tons. The limited time available for construction of military port facilities requires that pile driving equipment be as efficient as possible.

Dredging equipment:

Dredging in conjunction with military port construction projects allows a port to service large vessels without first lightening them to reduce their draft. It also permits facilities to be constructed closer to shore with a net reduction in both the total construction effort and materials required. Also, dredging may in some cases be more efficient than land-based operations for moving fill material and borrowing of aggregate. Transportation of dredges to the theater of operations is a major problem, as is the availability of dredges and crews for use in early stages of deployment.

Conclusions:

A study of past reports of port construction activities indicates that there is a general lack of marine construction equipment of adequate capacity. Containerization of cargo passing through military ports requires that new facilities be designed. However, design live loads imposed by containers and container handling equipment must be determined. This will require some knowledge of equipment that will be employed in the future. The Seabee and LASH barge ships offer a means of delivering large prefabricated structural components and large floating equipment to an overseas theater much faster and more reliably than previously possible. Their cargo could include: a) pier and wharf modules; b) 24-in. cutterhead dredges; c) construction barges; d) tanker mooring terminals; e) floating cranes; f) causeway sections; g) landing craft and harbor craft.

- The wide variation in the configuration of commercial roll-on/roll-off ships precludes the development of a standard facility to service them.
- Reel-type pipe laying barges are in use commercially and offer a means of rapidly installing submarine pipelines up to 12 in. in diameter. This equipment can be installed on DeLong "A" barges presently in the Army's inventory.
- A rigid-arm tanker mooring terminal investigated during the study appears to possess several advantages that would be of value to military engineering: a) rapid installation
  b) simplicity
  c) no need for special installation equipment.
- The DeLong self-elevating barge has demonstrated its adequacy for use as a discharge facility for existing break-bulk general cargo vessels. However, a thorough analysis must be made if these units are to service vessels with displacements exceeding 20,000 tons in 35 ft or more of water at sites where currents run perpendicular to the axis of the pier, or in areas where the approach velocities may exceed 0.5 ft/sec perpendicular to the pier face.
- Various types of large-capacity container cranes can be mounted on the decks of DeLong barges, but a detailed structural analysis should be made for each piece of equipment selected. In most cases, modifications will be necessary to adequately strengthen the structure.
- If installed at exposed locations, DeLong barges should be equipped with adequate fendering. The use of large rubber tires should not be expected to offer adequate protection except when small vessels are involved. The Bridgestone Super-Arch Fender (FV 009-5-3 or FV 009-6-4) appears to be the most practical for fendering at exposed locations.
- Caissons and jacks left extending above deck level of elevated piers will hinder the operation of truck- and crawler-mounted whirley cranes. A thorough settlement analysis should be performed prior to welding off the spuds. This analysis should preferably include the recording of time-settlement data for each caisson.
- One-dimensional stress wave analysis indicates that yield stresses may be exceeded in the DeLong caissons during driving if a massive soil plug is permitted to form at the bottom. The stress wave analysis also indicates that

not less than a 120,000-ft-lb hammer should be employed to drive the caissons.

- DeLong "B" barges can be transported to the top deck of the Seabee barge clipper provided that approximately 50 ft of the stern of the barge is removed.
- There is a need for a small spud barge which can be transported to the theater of operations aboard a barge ship and be employed as a prefabricated module. This barge should also be capable of serving as a flat-deck cargo or construction barge.
- The relative surfacing requirements developed for representative container handling vehicles provide data for comparison of surfacing requirements as a function of vehicle characteristics. The relative surfacing requirements developed for this investigation show that it is absolutely essential that surfacing requirements be evaluated prior to selection of container handling equipment in order to minimize construction effort associated with provision of adequate operating and storage area at military ports.
- The vehicles considered do not generally have adequate operational capability for use in over-the-beach operations.
- Unsurfaced soil should not be considered for storage and marshalling areas where the design traffic volume is much greater than 200 passes.
- M8A1 landing mat is not adequate for general use as surfacing for storage and operating areas at military ports without restricting the types of equipment employed and/or the gross weight of containers. Only two pieces of equipment, the tractor-trailer and the Shoremaster are suitable for continuous operations on M8A1 landing mat.
- It was not possible to determine the exact thickness of flexible pavement required for each piece of sample equipment. The reason for this inability was that no statistical data were available to allow correlation of the number of passes being applied to a given section of pavement with the number of containers being handled. Also, no data were available on the statistical distribution of container weights.
- The surface area requirement varies considerably with a host of different parameters. It is apparent that up to 20 acres of marshalling and storage area may be required for each container ship berth, depending on the type of operation.
- Sufficient information is not available on the operational traffic pattern of container handling equipment.[23]

II. "TRENDS IN NAVY SHIPS AND NAVY PORTS

Changing requirements for port capacity and technology have resulted in consideration of many new port design, construction and operations concepts. Navy ports must, in the future, be able to handle ship services, repairs and conversions on a ship systems basis. Future naval ships are expected to be increasingly equipped with plug-in systems models in the weapons, communications, ship services, power plant, navigational and other systems. These systems are expected to be handled in one piece and to be replaced by preassembled and pretested systems modules.

Many of these ship system or subsystem modules are expected to be unmanned and therefore result in crew reductions in the future. This, in turn, may change life support and other requirements.

The above as well as basic naval ship design and strategic considerations are expected to result in significant changes in navy port requirements.

Trends in Navy Vessels

Many studies of characteristics of future navy vessels have been performed, and forecasts of size, function, and performance vary widely. Yet, among all these conflicting projections, there are many consistent factors. These can be summarized as follows:

1. The size of capital ships such as aircraft carriers, helicopter carriers, assault vessels and other major combatant ships will gradually become smaller to reduce investment costs, energy costs and vulnerability while maintaining improvements in payload systems effectiveness.

2. High performance vessels such as large, 200-300 ton surface effect ships and hydrofoils will become an integral part of the ASW and surface combattant fleet.

3. Novel multihull catamaran, trimaran, semi-submerged catamaran vessels will become operational for high performance, long endurance types of missions by 1990. Some of these hullforms will provide the platforms for future missile destroyers, as well as replace conventional hullforms in some capital ship types. These types of vessels can be expected to have significantly larger beam and possibly draft for an equivalent displacement.

4. It is expected by some, that small fast missile and ASW vessels will constitute an important segment of the fleet by 1985. This would result in a significant increase in the number of active U.S. Navy vessels.

5. Manning of Navy surface vessels is generally expected to decline by a negative exponential function of about 3% and a resulting convergence of vessel manning to 62% of present manning levels over a 10 year period.

6. Navy ship propulsion will be increasingly gas turbine, fast and medium speed diesel

and nuclear propulsion plants. In many future naval vessels combined or hybrid plants of the above energy conversion systems types will be used to more effectively cover the required power spectrum. Fuel or energy efficiency is expected to become a major design criteria from a cost as well as ship displacement and endurance point of view. Gas turbine and diesel plants will be largely overhauled by replacement of the shipboard plant by an overhauled unit. As a result, both size and weight of machinery parts handled in a Navy port are expected to increase substantially.

7. Navigational and communications system are expected to be modularized within 10 years and ships delivered thereafter will largely service these by removal and replacement of the complete module.

8. A major development affecting navy ship/port interface will result from increasingly stringent environmental control requirements. As it is not practical or feasible to segregate ballast on most naval vessels (including navy oilers), extensive land based storage and oily water separation/treatment plants will be required in many navy ports. The same applies to sewage treatment, and solid waste disposal methods.

9. Ship supplies (consumables, spare parts, etc.) are expected to be loaded on board navy ships in prestored supply containers of various sizes (depending on ship types) by 1985. They would be mechanically handled on board the navy ship and be part of the shipboard store system. Navy port will therefore be required to handle fully loaded store containers (reefer, ventilated, insulated, ammo, lub oil, solvent, etc.).

10. The availability of portable mechanized bull cleaning devices, which permit unerwater hull cleaning while alongside is proving increasingly popular and may be accepted as practice by the U.S. Navy. This would result in improvements in fuel efficiency but would require changes in ship mooring method so as to provide safe access to ships from all sides during underwater hull cleaning.

11. New technology to facilitate and improve the safety of ship mooring is being developed by large tanker operators. It consists of laser assisted mooring controls and various shipboard and dockside devices such as constant tension winches, hydraulic arms, pivoted linkages and more. These new mooring techniques are generally designed to reduce docking/undocking time, reduce docking manpower requirements, and increase docking safety. Although of primary use for large vessels they are expected to be in use for Navy ship docking within 10 years.

12. Fueling, deballasting and other liquid transfer between Navy ships and shore is expected to be subject to major changes, which eliminate manual hose handling on board and on the pier. Mechanical loading/discharge arms are expected to come

into use within a reasonable time.

13. Ship painting and surface treatment is expected to be performed less frequently and under more strictly controlled conditions as more effective exotic coatings become standard. This will require special environmental control facilities to be provided by Navy ports.

The above are just some of the major trends expected in Navy ships over the near to medium term. There are obviously many unpredictable developments caused by unforseen threats, new technology, political or environmental replacements, changes in strategy and more.

In summary, several factors emerge from a review of potential Navy ship developments:

a) Navy ships will generally decrease in displacement but not necessarily size, as different hull forms are adopted.

b) High performance type vessels will enter the Navy arsenal in significant numbers by 1985.

c) Internal combustion (gas turbine, diesel, etc.) plants will increasingly replace steam turbine plants on non-nuclear plant propelled vessels.

d) Manning levels will on the average be 1/3 lower by 1985 than to date.

e) Interservice time for repair and overhaul will increase and many repairs and overhauls will be performed on shore by replacement of shipboard modules by overhauled module.

f) Navy ships built after 1985 will be largely composed of a modularized hull, as well as modularized power plant, auxiliary plant, living, weapons, communications and navigational systems.

Trends in Navy Ports

As a result of the expected development in Navy ship design and operations major changes in the design, capacity, technology and operational procedure of Navy ports may be required before 1985. Because of the rapid change in ship technology and the comparatively long lead time between ship concept development and delivery, many naval vessels today undergo plan conversion before delivery of even the first vessel. As Navy port facility requirements change with the fleet composition, we find similar problems of built-in obsolescence in Navy port development. Various approaches have been advocated or tried to reduce the effects of built-in obsolescence, such as:

a) Reduction of lead time to keep design more up to date and thereby reduce time between delivery and obsolescence.

b) Modularization which permits effective sub-system replacement to maintain technology.

c) Flexibility of design to assure Navy port facilities can accommodate changing technology and requirements of Naval vessels.

d) Relocatability of some Navy port facilitties to permit use of different onshore and offshore sites, as strategy and fleet service demand changes.

Most Navy ports consist of old conventional port

facilities such as piled finger or marginal piers (with narrow aprons), fixed rail or mobile boom cranes, exposed fuel, water and air pipes and similar services and equipments. Few would be able to effectively handle modularized ship systems (or subsystems) such as complete gas turbine - gear sets, diesel engines, communication modules and more. Lifting, handling, and load bearing capacity is severely limited at most Navy ports. There is also the problem of port siting from the point of view of sufficiency of access and maneuverability as well as vulnerability. Most Navy ports are at old well known sites and have limited access depth and width, as well as restricted alongside depth and other restrictions. Most are located some distance from deep open waters which implies significant delays in getting vessels into full speed deployment under emergency conditions. In fact, because of location and configuration, of many navy ports a significant number of navy vessels would become a sitting duck during a sudden unprovoked attack (Pearl Harbor). As a result the trend in future navy port design may be toward readily relocatable ports or port components, which are completely self-sufficient and can be moved as the operational or strategic need for a move arises.

Expected trends in Navy ports can be summarized as follows:

1. NAVY PORTS WILL BE BETTER EQUIPPED AND INCLUDE FACILITIES FOR THE EFFECTIVE HANDLING OF LARGE, HEAVY, OUTSIZED SYSTEMS AND SUBSYSTEM MODULES.
2. THEY WILL BE LARGELY SELF-SUFFICIENT, AND INDEPENDENT OF OUTSIDE SERVICES SUCH AS POWER, WATER, GAS, ETC.
3. THEY WILL INCLUDE EFFECTIVE MEANS FOR THE RECEIPT, TREATMENT AND DISPOSAL OF OILY WATER, SEWAGE AND SOLID WASTE FROM NAVY SHIPS.
4. NAVY PORTS WILL HAVE INTEGRATED CONTAINERIZED SUPPLY SYSTEMS.
5. THE DEVELOPMENT OF PREFABRICATED RELOCATABLE PIERS, EQUIPPED WITH INTEGRAL SERVICES AS WELL AS TOPSIDE FACILITIES IS EXPECTED TO HAVE A MAJOR IMPACT ON NAVY PORTS. SUCH PIERS CAN BE:

   a) FLOATING PONTOONS
   b) JACK UP PONTOONS (DeLONG, HYDRANAUTICS)
   c) GRAVITY STRUCTURES
   d) CATAMARAN PIERS
   e) OTHERS

   CONFIGURATIONS OF SUCH PREFABRICATED, RELOCATABLE PIER CONCEPTS ARE SHOWN IN FIGURE N-R. THE TYPE, CONFIGURATION, AND FOUNDATION OR ANCHORING OF PREFABRICATED PIERS WILL DEPEND ON:

   i. SOIL AND SUBSOIL CONDITIONS
   ii. TYPE OF SERVICE INCLUDING SHIP TYPES TO BE ACCOMMODATED.
   iii. OPERATING LOADINGS.
   iv. WAVE, CURRENT, SEDIMENT TRANSPORT AND OTHER ENVIRONMENTAL CONDITIONS.
   v. AVAILABILITY OF STRUCTURAL MATERIALS.

   THERE ARE SIMILARLY GROWING OPPORTUNITIES FOR THE USE OF FLOATING OR FLOATABLE PIERS, PONTOONS, CATAMARANS, SEMI-SUBMERGED CATAMARANS AND OTHER TYPES OF PLATFORMS. THESE MAY BE SUPPORTED SOLELY BY DISPLACEMENT OR COULD BE OVERSUPPORTED BY ATTACH-

MENT TO TENSION LEGS, BUOYS OR ANCHORS.

SUCH ATTACHMENT LARGELY ELIMINATES THE EFFECT OF THE WATER INTERFACE. SIMILAR IMPROVEMENTS IN FLOATING PLATFORM STABILITY CAN BE ACHIEVED BY SUBMERGING MOST OF THE DISPLACEMENT VOLUME OF THE PLATFORM WELL BELOW THE WATER SURFACE OF AIR/WATER INTERFACE.

IMPORTANT CONSIDERATIONS IN THE ADOPTION OF PREFABRICATED MODULARIZED PORT FACILITIES WILL BE:

a) STRATEGIC ADVANTAGES OF RELOCATABILITY.
b) REDUCTION IN VULNERABILITY TO ATTACK
c) EASE OF EXPANSION OR MODIFICATION OF NAVY PORT FACILITIES.
d) INDEPENDENCE OF SHORESIDE FACILITIES OR SERVICES.
e) FLEXIBILITY IN OPERATION INCLUDING MOVEMENT INTO DEEPER WATER TO ACCOMMODATE LARGER AND/OR DEEPER VESSELS.

(PREFABRICATEL AND/OR MODULAR PORT FACILITIES WOULD USUALLY BE EQUIPPED WITH INTEGRAL POWER, FLUID AND OTHER SYSTEMS, AS WELL AS INCORPORATION OF TANK AND OTHER STORAGE COMPARTMENTS.

6. DOCKING AND MOORING SYSTEMS ARE EXPECTED TO BE SEMI-AUTOMATED WITHIN THE NEXT 10 YEARS TO REDUCE DOCKING/UNDOCKING TIME LOSS, IMPROVE DOCKING SAFETY, AND REDUCE OR ELIMINATE MANUAL LINE HANDLING AND OTHER MANUAL OPERATIONS DURING DOCKING.

THERE ARE NUMEROUS DEVELOPMENTS IN OTHER PORT RELATED AREAS, WHICH ARE EXPECTED TO AFFECT NAVY PORT DESIGN, CONSTRUCTION AND OPERATION IN FUTURE.

AMONG THESE ARE:

a) CONTINUOUS (PNEUMATIC, HYDRAULIC OR MECHANICAL) SEDIMENT AGITATORS TO REDUCE OR ELIMINATE THE NEED FOR MAINTENANCE DREDGING ALONGSIDE PIERS.

b) SUPPLY CONTAINER CONVEYOR OR MONORAIL DELIVERY AND TRANSFER SYSTEMS.

c) AUTOMATIC LOADING ARMS FOR CONNECTING FUEL AND OTHER PIPELINES TO SHIP WITHOUT MANUAL HOSE HANDLING.

d) Other

The potentially useful technological developments are very numerous. 24.

FOOTNOTES

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I. General

II. Mineral Accretion

III. Saltwater - Ionic Transmission

- A. Ions
- B. Membranes
- C. Nerves

IV. Port Function and Movement

- A. Ports
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V. Countercurrent Exchange

VI. Ports in Cold Regions

VII. Ports in Desert Regions

- A. Desert Ports
- B. Trees
- C. Soil
- D. Energy

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